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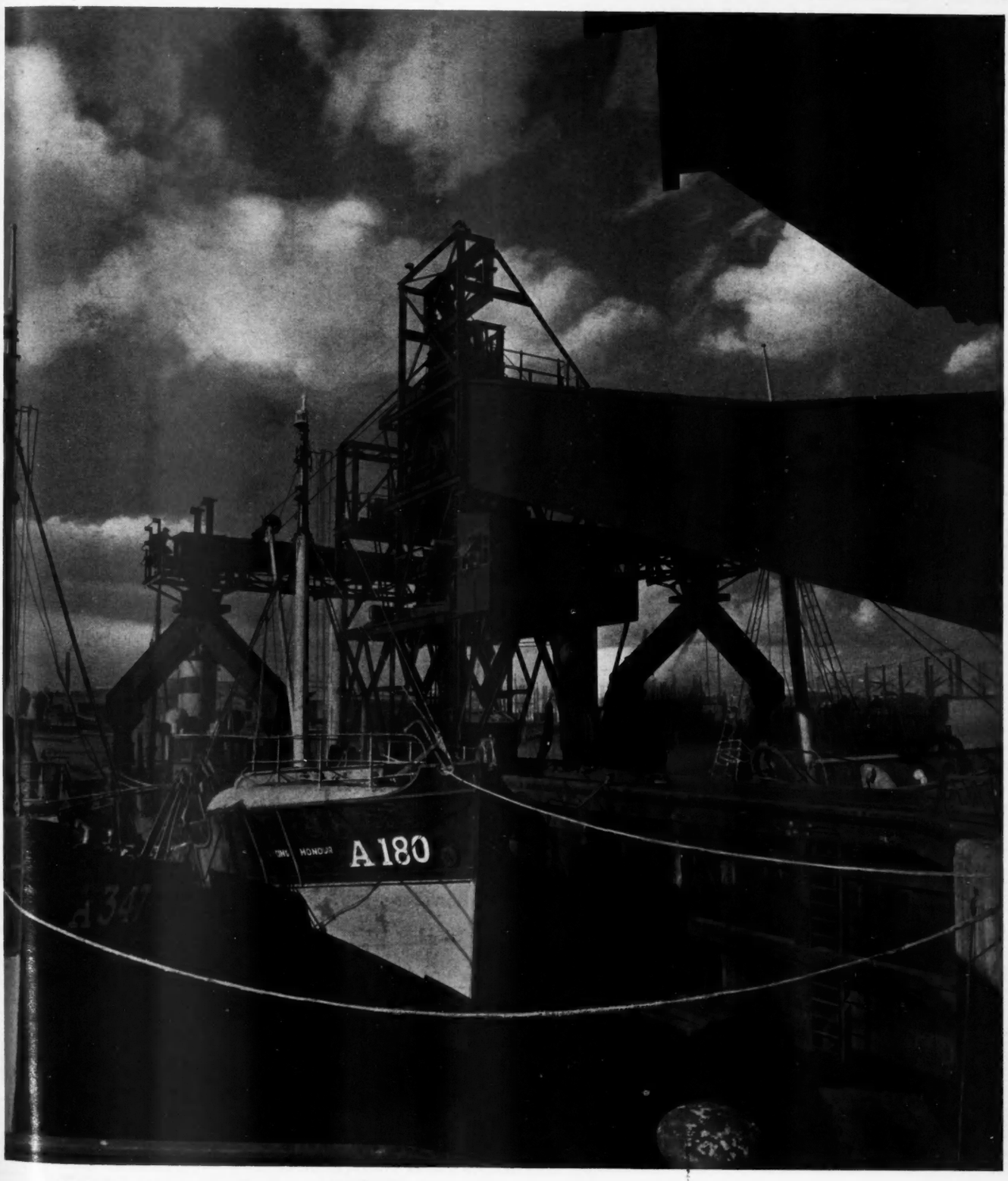
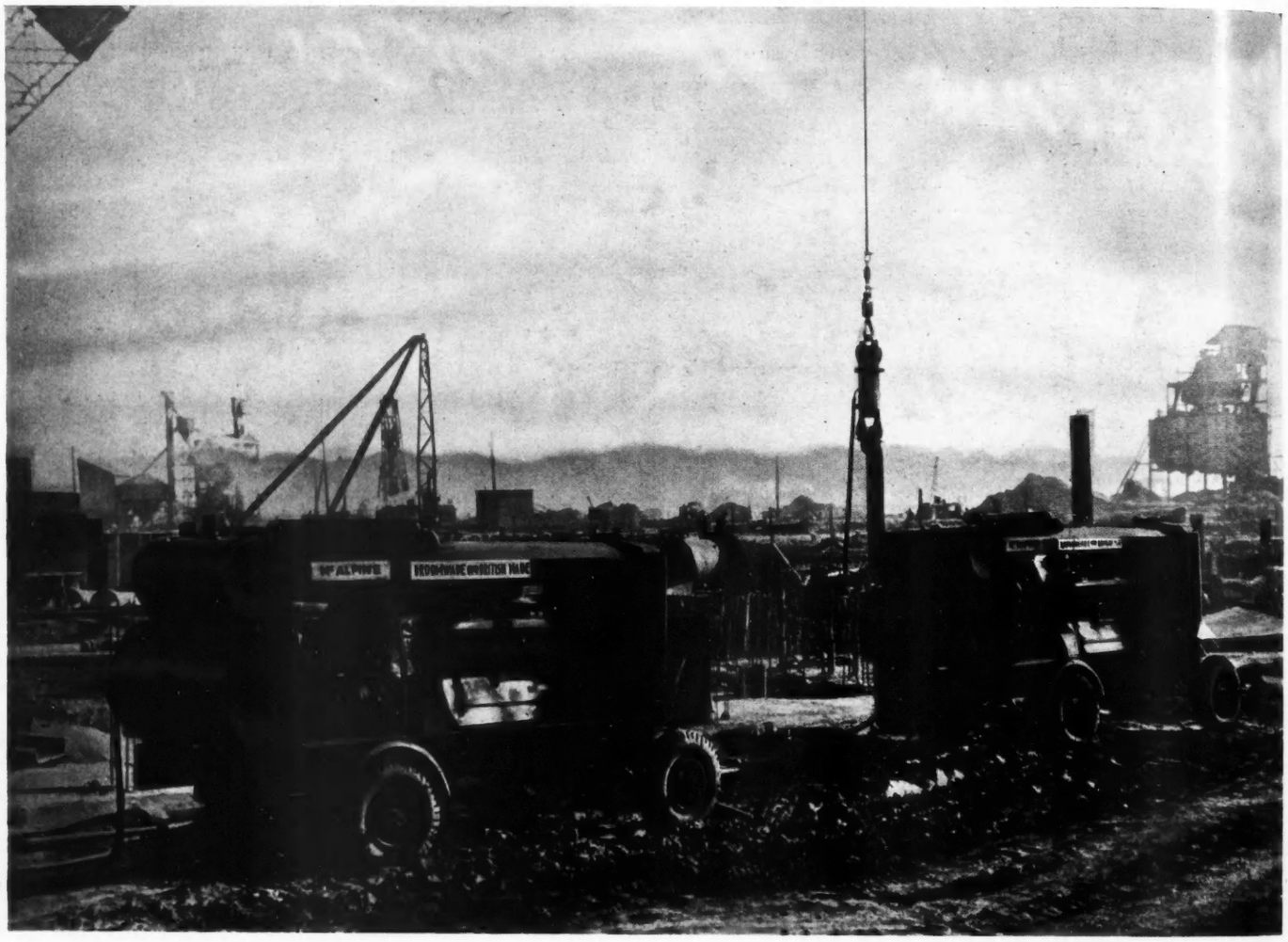


TRAWLER COALING PLANT AT ABERDEEN.

Achievement . . .



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154 SAS

AIRCRAFT ENGINE TEST-HOUSE FOR "SWISSAIR" AT ZÜRICH.

As part of a programme for centralising and modernising their maintenance and overhaul services, Swissair have installed a new engine test-house at Kloten Airport, Zürich. The test-house, illustrated in Fig. 1, which has now been in operation for just over two years, is one of the most efficient installations in existence, in that it is capable of providing an almost continuous "throughput" of engines under test. The specifications and the overall responsibility for the design and the installations were under the supervision of Mr. G. Westermann, head of the Swissair technical planning department; and the electrical problems and instrumentation were the responsibility of Mr. D. Brentano, of the same department. To install an engine on the test stand requires less than 20 minutes, whereas on earlier installations a period of several hours may be required. This has been accomplished by the selection mainly of electrical indicating instruments, by the use of mechanical control linkages, and by the design of the engine attachments. It is gratifying to learn that contracts for the test plant and soundproofing equipment were awarded to two English firms, in competition with an American company. The engine test plant was designed and installed by Messrs. Heenan and Froude, Limited, Worcester Engineering Works, Worcester. Messrs. Horace W. Cullum and Company, Limited, Flowers Mews, London, N.19, supplied the acoustic splitter panels and associated steelwork, which are fixed in the intake and exhaust tunnels, and acted as consultants generally on the soundproofing of the building. The architects were Messrs. Casetti and Rohrer, Zürich, and the engineers responsible for the structural design were Messrs. Schubert and Schwarzenbach, Zürich.

Layout and Construction of Building.

The layout of the test-house is illustrated in Fig. 2. The overall length of the building is 54 m., the width 20·3 m., and the height 7·7 m. Two test cells extend along the full length of the building; one of these cells is equipped for testing piston engines and the other, not yet in use, will eventually be fitted out for testing gas-turbine engines, when Swissair add turbine-driven aircraft to their fleet. At present, three types of engine are in service with Swissair—Pratt and Whitney twin Wasp R.1830 engines developing 1,200 h.p., at take-off, fitted in their D.C.3 fleet; Pratt and Whitney twin Wasp R.2000 engines of the D.C.4 fleet, developing 1,450 h.p.; and Pratt and Whitney double Wasp R.2800 engines, developing 2,400 h.p., in the D.C.6 and Convairliner fleets.

At the forward end of the test-house, a preparation room is located between the two test cells, and communicates with them; in this room the engines delivered from the overhaul shops are prepared for test. A short flight of steps at the rear of the preparation room leads to a door giving access to the control room, from which both test cells can be controlled and observed. Below the control room is a room in which plant and equipment directly concerned with the engine tests is housed. The plant room has doors leading into the test cells. Aft of the control room are test stands for testing superchargers and hydraulic pumps, still under construction. The air-conditioning plant and the main switchroom are situated aft of the plant room. As are all the buildings on the airport, the test-house is built on piles 7 m. long, which extend below a water layer some 3 ft. underground. The building is of reinforced concrete, with single walls 12 in. thick. The lower part of the inside walls has a cork insulation layer built into the concrete. Above this, sound-insulating material surrounds the walls and ceiling of the control room and preparation room, and the side walls of the test cell forward of the engine; it is discontinued aft since it would be liable to become saturated with oil and, therefore, ineffective.

Preparation Room.

To ensure that time which could be spent in running the test bed is not wasted during engine installation, most of the work of preparing an engine for test is carried out in a specially-equipped preparation room, illustrated in Fig. 7, on Plate XXIII. A universal tubular-steel engine mounting has been designed, on the front of which is an adaptor plate constructed to take all types of engine operated by Swissair, with suitable bores for accommodating the pipework and controls. For setting up an overhauled engine ready for test, the tubular mounting is attached by four horizontal bolts to one of the permanent steel-joist frameworks that can be seen in Fig. 7. All the fuel and oil piping, etc., is then attached ready for securing by quick connectors to a mounting ring in the test cell. A pressure-transmitter box, suitably designed for each type of engine, is fitted at the rear of the engine mounting, to which most of the engine pressure lines—air pressure, fuel pressure, oil pressure, etc.—are connected. From the transmitter box the pressure signals are electrically connected, through a multiple-point plug connection on the test-cell mounting ring, to the control desk. The test propeller, with an electrically-operated variable-pitch mechanism, is then fitted to the engine. To provide adequate cooling flow, the

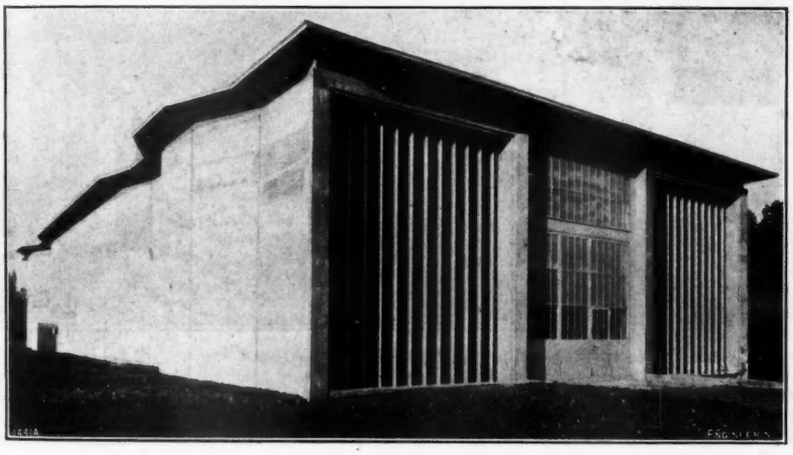
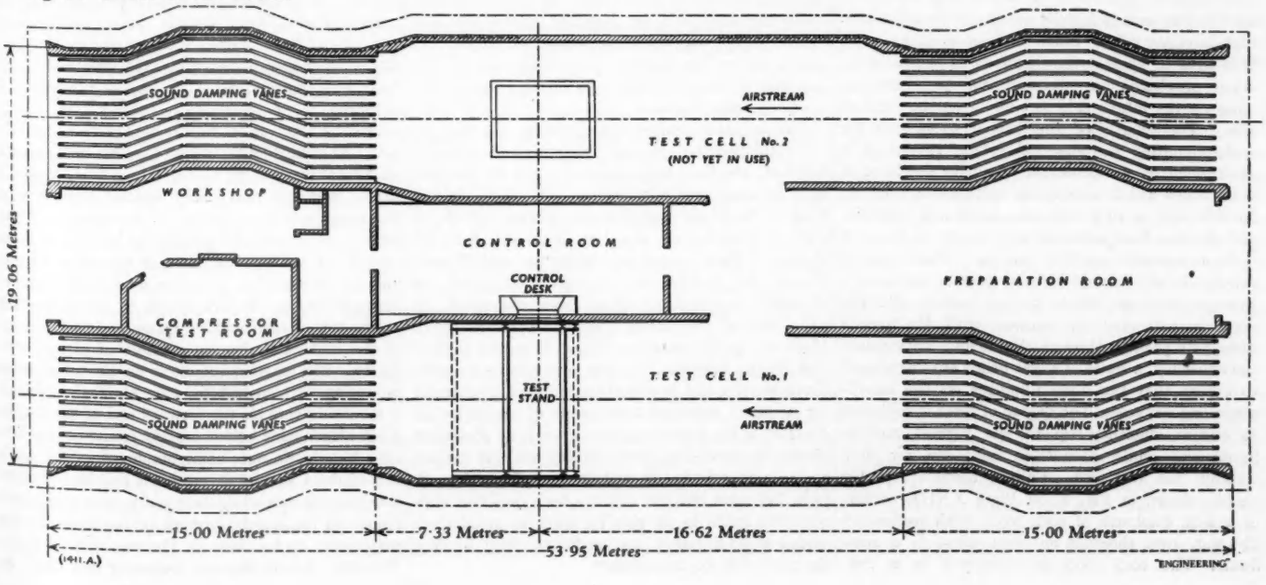


FIG. 1. ENGINE TEST-HOUSE AT KLOTEN AIRPORT.

Fig. 2. LAYOUT OF TEST HOUSE.



AIRCRAFT ENGINE TEST-HOUSE FOR SWISSAIR AT ZÜRICH.

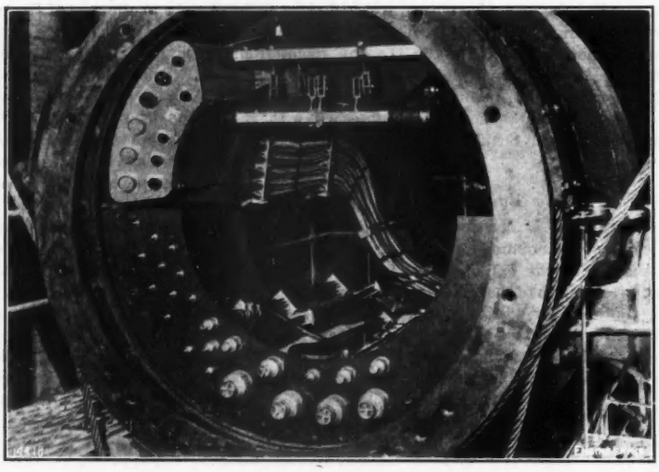


FIG. 3. NACELLE AND MOUNTING RING.

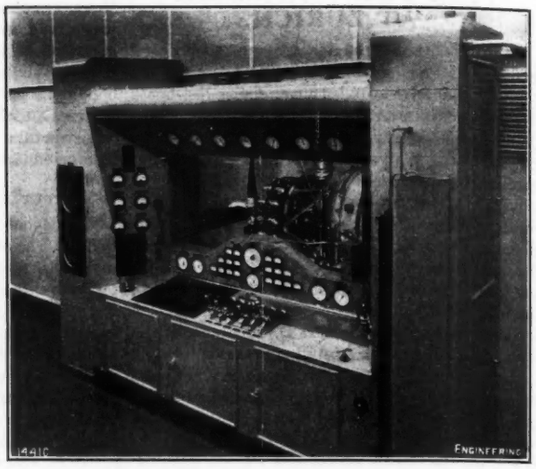


FIG. 4. CONTROL DESK.

propellers are designed with special sleeves. Finally, before the engine is taken into the test cell, a split cowling is fitted. This cowling can be swung open to permit adjustments to be made to the engine on the test bed, without removing the propeller.

A system of overhead hoists travelling on rails is provided in the preparation room for handling the engines and for transferring them to the test cell. The track, however, is not continuous with that of the test cell, being broken at the doors between the two rooms, in order to avoid transmitting noise from the test cell into the preparation room. When the double communicating doors are opened, a bridge track can be manually swung into position, connecting the two tracks, as shown in Fig. 8, Plate XXIII, in which the handle and cables for swinging the track can be seen. Before the doors can be closed, the bridge piece must be turned to lie parallel between them. Also to avoid noise transmission, the folding doors when closed abut on to sloping sills, forming seals.

TEST CELLS.

The test cells form, in effect, rectangular tunnels for the large mass of air driven through the test cell by the propeller in absorbing the power of the engine; this current of air keeps the engine cool. The problem of the acoustic consultant is to permit the free entry and discharge of this large volume of air without permitting the escape of the associated high-intensity noise. Since the noise travels equally well with or against the direction of the air flow, equal provisions are necessary for absorbing the noise on the intake side as well as on the exhaust side. The length of the tunnel extensions for accommodating the sound-absorbing treatment is determined by a calculation based on the level of noise which will be acceptable outside the building. In this case, a very low noise level was required, and this has been achieved in a length of 45 ft. of Cullum acoustic splitter panels. These panels sub-divide the tunnel into a number of narrow passages through which the air passes, and the noise is extracted by contact with the panels during its passage through the ducts. To increase the efficiency, a series of slight bends are introduced to ensure that the noise impinges on the sound-absorbing surfaces. The degree of bend is sufficient to ensure efficiency up to the highest audible frequencies while permitting adequate air flow through the test cell. Cullum acoustic splitter panels, shown in Fig. 9, on Plate XXIII, consist of a 4-in. thickness of rock wool, with perforated 22-s.w.g. steel sheeting on both sides, in a steel frame. The rock wool is enveloped in a rot-proofed cotton fabric to prevent any particles seeping out through the perforations on each face. All the steelwork on the panels is galvanised, and the whole structure is extremely rigid in order to resist the turbulence of the air stream from the propeller. Standing immediately outside the intake or exhaust tunnel only the very low-frequency components of the noise, together with a soft hiss, can be heard, with the engine inside running at full speed. When the engine is not being run, the end openings of the test cells can be closed by manually-operated roller shutters.

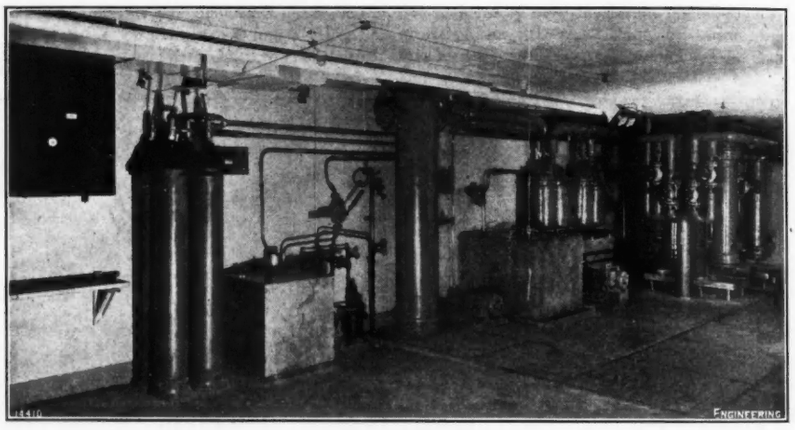


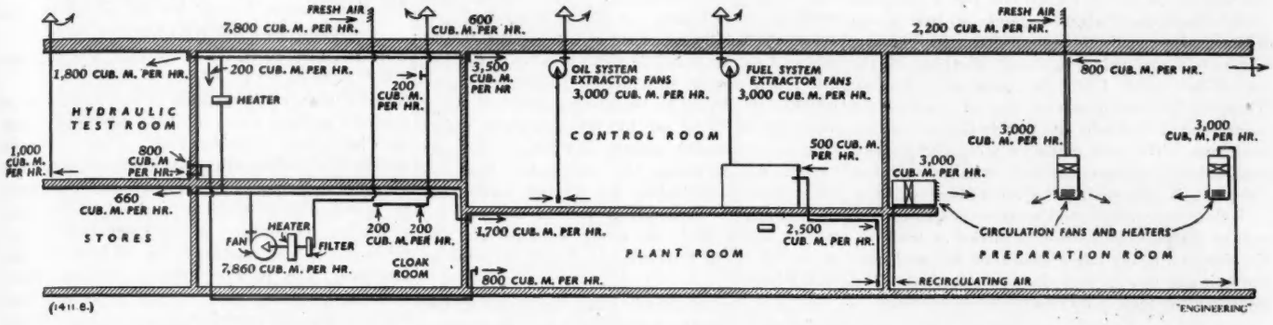
FIG. 5. PLANT ROOM.

The test plant, as already mentioned, was designed and installed by Messrs. Heenan and Froude, Limited, who have been responsible for the installation of many aircraft engine test plants in the United Kingdom and Europe, among which, it may be recalled, is the test house at Schiphol airport, Holland, again in conjunction with Messrs. Horace W. Cullum and Company, Limited, as acoustic consultants, which was described on page 295 of our 169th volume (April 1, 1949). Much of the equipment at Kloten is similar to that installed at Schiphol, but the newer Swiss installation is simpler and, as already mentioned, is arranged for a much speedier turn-round of engines. In contrast to the Schiphol plant, there is no crankcase blower to provide a forced cooling draught for the engine under test. It will be seen from Fig. 2, page 769, that the test cell has been designed with adequate space to provide for such an installation should it be required, but so far auxiliary cooling has proved to be unnecessary.

Fig. 10, on Plate XXIII, shows an engine installed in the test cell ready for test. Access for fitting the engine on its cradle prior to testing is provided by permanent staging and by a hydraulically-operated elevating platform, which is retracted into the floor during the test. The hydraulic ram operating the elevator is controlled by compressed air from the main compressed-air system serving an adjacent aircraft-overhaul shop. This system is fed by a 42-h.p. compressor delivering 320 cubic metres per hour at 8 atmospheres. The test bed, like that at Schiphol, is of the cable-suspended type, and is carried by two vertical frames built up from 10-in. by 8-in. rolled-steel joists, braced together to form a stiff structural framework, and anchored to a foundation block, which is completely isolated from that of the main building in order to minimise the transmission of vibration through the building. A test nacelle, of welded-steel plate, is suspended at each end by three 1-in. diameter steel ropes, secured through resilient rubber blocks to corner brackets at the top of each vertical frame and to the centre of the bottom horizontal member of each vertical frame. The engine, mounted on its tubular-steel mounting, is attached by four horizontal bolts to a mounting ring on the forward end of the nacelle. Each attachment bolt is quickly secured and locked by a handle, no nuts being employed. The nacelle is restrained against thrust loads by two horizontal side tie-rods extending diagonally from attachment points on the nacelle just aft of the forward cable suspension, to brackets on the rear vertical frame. The side tie-rods also are resiliently mounted. As

AIRCRAFT ENGINE TEST-HOUSE FOR SWISSAIR AT ZÜRICH.

Fig. 6. ARRANGEMENT OF AIR-CONDITIONING EQUIPMENT.



seen in Fig. 3, opposite, which shows the mounting ring and the nacelle interior, the nacelle forms a conduit for the engine control runs, fuel and oil lines, and electrical wiring. At the forward end it carries an annular panel on which are grouped self-sealing connectors for the fluid pipelines and plugs for the electrical cables. A streamline duct extending transversely from the nacelle conveys the various engine and instrument lines into the control desk in the adjacent control room.

For simulating the effects of reduced air density at high altitude, the engine air intake is connected to an air-depression pipe passing below the building from a chimney aft of the plant room, open to atmosphere. Air entering this pipe passes through filters and through a motor-operated depression valve which can be remotely controlled from the control desk. Within the test house, the air-depression pipe is led up through the plant room and into the control desk, through the forward part of the stream-line duct into an annular duct surrounding the test nacelle. From the annular duct, an air trunk is led forward to the engine air intake, as may be seen in Fig. 10. To protect the pipe from the effects of a backfire, an explosion valve is fitted in the pipeline, at the top of the plant room.

CONTROL ROOM.

The interior of the control room is shown in Fig. 4, opposite. Precautions have been taken in the design to prevent the penetration of noise into the control room. All openings for pipes and services are acoustically treated, and a triple-glazed observation window in floating frames avoids any weakness at this point. Acoustic treatment on the ceiling and upper walls of the control room prevents the magnification of any sounds by ensuring a short reverberation time. Apart from the apparatus for recording the engine-oil flow, which is enclosed in a separate cabinet not shown on the illustration, all the engine controls and instruments are grouped on the desk. The control levers for the throttle, mixture, fuel cut-off, constant-speed unit, supercharger gear change, and a spare lever, are grouped on the front of the desk. All these controls are mechanically linked with the controls on the engine. To the left of the control levers is a switchbox for the engine-starting circuits, fuel pumps, etc., which houses also a system of indicator lights. Most of the control-desk instruments are made by Swissair; this arises from the fact that, in contrast with many other air lines, Swissair carry out overhauls on every item of aircraft equipment, including instruments and radio, and are therefore well equipped for manufacturing their own instruments.

The vertical panel behind the engine controls contains the engine tachometer, the individual cylinder-head temperature gauges, and pressure gauges for the fuel pressure, main engine-oil pressure, torquemeter pressure, and boost pressure. As already noted, most of these pressure gauges are of the remote-indicating type, some actuated by transmitters on the engine mounting, and some are of the fluid-pressure diaphragm type, thus avoiding the introduction of inflammable fluids and gases into the control desk proper. In this respect the installation differs from that at Schiphol. The right-hand side of the desk consists of a separate steel-walled cabinet enclosing the fuel pipelines and measuring apparatus. The main fuel-storage tanks and three 1,000-gallons-per-hour fuel pumps are underground outside the test house. Two pipe lines (one for 100/130 grade fuel and the other for 80-octane fuel) are led from these tanks through the fuel-control cabinet, where the rate of fuel flow is measured in an Amal flowmeter, visible through a glass window, and thence through the streamline duct to the engine. A low-octane/high-octane selector cock is provided on the control desk adjacent the fuel-control cabinet. All engines in service with Swissair operate on 100/130 grade fuel; 80-octane fuel is used to flush the engine after test to prevent the formation of lead deposits. The fuel-control cabinet also houses an Amal flowmeter for measuring the rate of water/methanol injection, when this is used; and Hobson boost and depression gauges for measuring the air pressure at the supercharger and at the carburettor entry. At the top of the fuel-control cabinet is an extractor fan which serves for general ventilation of the control room as well as for removing fuel fumes. The main switch starts up all the fume-extraction fans.

On the front wall of the cabinet at the left-hand side of the desk are carburettor air-flow gauges. The inner panel of this cabinet houses thermometers for the engine-room air temperature, and the engine-oil inlet and outlet temperatures. The emergency master switch controlling all the test-stand circuits is located on this panel, and so also is a warning light which indicates when any trace of metal is present in the oil at the engine outlet. The instrument for detecting metal particles depends upon the change of resistance in an electrical circuit caused by the passage of a metal particle past a closely-wound coil enclosed in a sleeve through which oil is circulated. Certain cut-out switches for disconnecting the safety circuits, to be described later, are also located on this panel.

Above the control-desk window are situated the engine-room airspeed indicator, the water/methanol injection pressure gauge, oil-pressure gauges for various oil feeds and the motor-operated depression valve-position indicator.

The oil-flow control cabinet, which is provided with an extractor fan at the top, is similar to that at Schiphol; it contains a 35-gallon electrically-heated oil-measuring tank from which oil is pumped by a circulating pump of 2,300 gallons per hour capacity, into the oil-circulation system, which will be described in more detail later. The oil from the engine outlet flows back through the streamline duct into a 20-gallon tank, known as the "rate-of-flow" tank, situated above the measuring tank and communicating with it through a "rate-of-flow" valve. The measuring tank is fitted with a Hobson Telegage for measurement of the oil consumption and the rate of oil flow through the system. The method of carrying out these measurements will be described later. Also within the oil-flow control cabinet is an electrically-heated replenishment tank, of 15 gallons capacity, for topping up the measuring tank with warm oil should its level fall too low.

In addition to the control desk and the oil-flow control cabinet, the control room contains a rectifier supplying a direct current of 400 amperes for starting the engine.

PLANT ROOM.

A photograph of the plant room, in which are located a rectifier for the general electrical services, an orifice-type flow meter for measuring the air flow through the carburettor, four carbon-dioxide bottles serving the fire-extinguishing system, a water/methanol storage tank and pump, various oil-system components, etc., is reproduced in Fig. 5, opposite. At this stage it is convenient to describe the oil-circulation system. During the course of a test, after the engine has warmed up, the engine pump performs the main work of circulating the oil through the system, the circulation pump in the control room merely serving to overcome frictional losses in the piping outside the engine. The circulation pump delivers oil, through a manually-operated temperature-control valve, either through, or by-passing, four Serck oil coolers of the constant water-flow type, to a Vokes twin-filter unit and thence through the streamline duct to the engine. The Vokes filters and the oil coolers can be seen on the right of Fig. 5. From the engine outlet, the oil returns, passing through the metal detector, through the streamline duct and by way of a second Vokes twin-filter unit in the plant room, up into the rate-of-flow tank in the control room.

At the start of a test, the circulation pump is unable to produce sufficient oil pressure for starting the engine, and an oil-priming pump, capable of delivering 300 gallons per hour at 80 lb. per square inch, is therefore provided in the plant room; this pump delivers heated oil from the measuring tank through a separate priming line to the bearings, etc., of the engine, and is shut down before the engine is started. Also within the plant room is an oil drain and refilling tank, which is used both for draining the measurement tank and also for refilling the replenishment tank, by means of the oil-priming pump.

Oil measurements are made as follows: to determine the rate at which oil is consumed by the engine, the valve in the base of the rate-of-flow tank is left open. During the test, which may last an hour or more, the level of oil in the measuring tank will gradually fall, since the amount of oil returned by the engine is less than that delivered to it. The weight of oil lost in the measuring tank

over the period of the test is read from the Hobson Telegage, which is calibrated in pounds.

To determine the rate at which oil is delivered to the engine, the test is carried out over a comparatively short period, about ½ minute, so that the oil losses in the engine can be neglected. In this case, the rate-of-flow valve is closed, shutting off the rate-of-flow tank from the measurement tank. Thus, as the test proceeds, the oil level in the measurement tank falls and that in the rate-of-flow tank rises. The time taken for a certain quantity of oil to leave the measuring tank, as indicated by the Telegage, is observed. The rate-of-flow valve is of hollow construction and constitutes an overflow weir so that, should the test be carried on too long, the rising oil in the rate-of-flow tank will spill over the weir and flow through the valve stem; thus the measurement tank is automatically replenished.

Safety Precautions.

As already mentioned, four carbon-dioxide bottles provide for extinguishing fires. Two of these bottles are connected by pipelines to the fuel-control cabinet in the control room, and the other two serve the test cell, fire-extinguishing nozzles being located at the carburettor air intake, in the streamline duct, and at various possible danger points around the engine. The system is manually discharged, the release handle for flooding the engine being on the control desk; those for flooding the fuel-control cabinet are provided adjacent to the exit doors so that they can be operated as the crew escape from the control room.

A comprehensive microswitch and relay system ensures that the engine ignition circuits cannot be completed unless the roller shutters in the test cells are up, the elevator platform is retracted, and the main doors from the preparation and plant room into the test cell are closed. In addition, the ignition circuit is broken by an adjustable overspeed switch if the engine exceeds a predetermined speed. A system of warning lights is also provided on the control desk to indicate the fault breaking the ignition system.

Air-Conditioning System.

A diagram of the air-conditioning system is reproduced in Fig. 6, page 771. The test cell and the control room are conditioned by warm air and are maintained under a pressure of 5 mm. w.g. above atmosphere. Fresh air is drawn into the building, through filters and then through heaters, by a centrifual fan with a capacity of 7,860 cubic metres per hour. Two systems of heaters are provided—hot-water radiators used during the winter when the central heating system is on, and electrical heaters for the spring and summer seasons. The main ventilating fan and air heaters are located in a small room aft of the equipment room. In this room is a thermostatically-controlled valve which regulates the entry of hot water to the radiators. The central heating system is located in the adjacent main aircraft-overhaul building, and serves this building, the hangars, and a new terminal building. The four boilers are oil fired, and are automatically regulated to maintain a constant water temperature. Extractor fans, each with a capacity of 1,700 cubic metres per hour, are located at the top of the fuel-flow and oil-flow cabinet; a smaller extractor fan serves the cloakroom. The preparation room, which is not under pressure, is separately ventilated by three fans with a capacity of 3,000 cubic metres per hour each and is heated by the main central-heating system.

Electrical System.

The electrical services are fed from a substation in the main aircraft-overhaul shop. Here, the incoming 16,000-volt main supply is transformed down to a 380-volt 50-cycle supply, which is brought into the main switchgear room in the test house, aft of the equipment room. In this room are located the main light, power and test-cell fuses, which are inserted directly into the 'bus-bars. The main light and power contactors are located in their respective fuse boxes. All the test-stand circuits are controlled by a master switch on the control desk. A safety switch is also provided in the test cell which can be switched off to disconnect the ignition circuit. The ventilation fans are automatically switched on by the test-stand safety switch. To guard against any danger of fuel vapour accumulating, the ventilation fans are automatically controlled by a time switch, so that, when the test cell is not in use and the master switch and all power switches are disconnected, these fans are run for 10 minutes in each hour.

From the main switch room, light and power cables are led to the various services. It is interesting to note that none of the components is flameproof, since such an installation, to be effective, would necessitate completely redesigned switches, leads and breakers, which were not available on the market. Furthermore, such an installation would not be completely explosion-proof, and would not therefore be of great practical value. The control-room light and power supplies are led to a control panel in the corner of the control room. An inverter provides a 26-volt 400-cycle supply for the electrical pressure transmitters and indicators, which operate on the Autosyn principle.

When the master switch in the control room is opened, it also actuates two magnetic valves in the fuel lines, cutting off the fuel supply to the control desk. These valves can also be actuated from the control panel. A delay switch in the oil-pump circuit maintains the oil pump running for half a minute after all the other services have been disconnected.

For starting the engine, a rectifier in the control room converts 380-volt alternating current to 28-volt direct current. The engine-starting circuits are controlled from the desk, provided that certain automatic safety circuits are all closed.

The control room is illuminated by neon strip lighting, supplied at 10,000 volts from two transformers in the control panel. These tubes have a life of 48,000 hours, and require no warming-up period. The desk itself is lit by ordinary 220-volt fluorescent tubes.

Test Schedule.

The complete engine test carried out at Zürich occupies about five hours, and comprises a series of 10-minute checks at gradually increasing revolutions during which the supercharger gear change and the satisfactory operation of the engine with rich and lean mixtures are observed. This is followed by longer periods of endurance running at 89 per cent. and 100 per cent. of the rated speed, during which the oil consumption and rate of flow are measured, and short periods of operation at rated and maximum revolutions with and without water-methanol injection in operation. An acceleration test is also carried out, and the operation of the engine at idling speed is also checked. After the test is complete, the engine is run for five minutes on 80-octane fuel to prevent the deposition of lead from the high-octane fuel, and the oil supply to the engine is changed over from the standard oil to one of a corrosion-inhibiting oil.

Direct-Current Valve Voltmeter.—Baldwin Instrument Co., Ltd., Dartford, Kent, are now manufacturing a direct-current valve voltmeter with the unusually high input resistance of 10 million megohms. Voltage measurements can therefore be made without appreciably disturbing the circuit under test, and the measurement of current as low as one milli-microampere and of resistances up to one million megohms is possible.

LITERATURE.

Die geometrischen Verhältnisse bei der Herstellung unregelmässiger Flächen.

By Dr. Ing. W. H. Gres. Springer-Verlag, Reichpietschufer 20, Berlin W.35. [Price 12 DM.]

Geometrical considerations in the production of irregular surfaces have not been adequately dealt with in books on machine tools. The book under review is a praiseworthy attempt at a systematic survey of the various surfaces which can be produced by metal-cutting machines, and of the methods which lend themselves to the production of such surfaces. It also correlates the surfaces and the processes. The regular surfaces such as plane, cylindrical, conical, spherical and helicoidal, however, are straightforward, and the irregular surfaces can only be classified on broad lines; thus the survey of the various surfaces is virtually an introduction. Moreover, as most of the surfaces considered are those which can be produced by machine tools, and as the descriptions and illustrations of the processes inevitably demonstrate the surfaces produced, the section of the book on the correlation of the surfaces and processes is necessarily a short summary. As a result, the discussion of the processes constitutes the largest part of the book.

This section is divided into the three groups: free-forming, reproducing, and generating processes. Sawing, filing, planing, milling, or grinding of previously marked-off contours, and also "free-hand" turning of bodies of revolution and similar manually-controlled applications of machine tools are cases of free-forming, the underlying principles of which are dealt with in a few paragraphs. Consideration of generating processes calls to mind, in particular, gear-cutting processes, a full treatment of which would require a comprehensive book. Dr. Gres devotes appropriate space to it, but also deals with other generated surfaces, such as those based on circles, cycloids, sinoids, and other curves. In this group also are the turning of ovals and the drilling of square holes.

The reproducing processes facilitate the production of a greater variety of shapes than the generating processes, and in a more economical way than the free-forming processes. The treatment of this important group occupies more than half of the book and accounts for about three-quarters of the illustrations. To it belong the many processes based on the use of templates, cams or drums, and also on true-to-scale drawings used in conjunction with photo-electric cells. Reproducing processes are not restricted to copying, but can be based on any representation of a shape in which one point in one system corresponds to one point in another. The production of right-hand and left-hand components from a common pattern, or of components which differ in size from the prototype is well known, as also is the production of the negative shape of dies and moulds from a positive tool or from a specimen, with appropriate compensation for the thickness of metal in the case of press tools. It is less well known that the elements which govern the shape can be distorted for the purpose of reducing the inclination of the curves along which the feeler or tracer is travelling, and that less-inclined curves can also be produced by providing two independent curves corresponding to the two directions of the co-ordinates. Closed contours afford particularly effective means for imparting to the tracer a more favourable motion, either by the expedient of stretched angles or by the use of conchoids of the curves to be produced, so that it is in some cases advantageous to transform the curve of the template into polar co-ordinates, even if the desired shape rather suggests parallel co-ordinates.

The numerous illustrations in the book are almost

AIRCRAFT ENGINE TEST-HOUSE FOR SWISSAIR AT ZÜRICH

(*For Description, see Page* 769.)

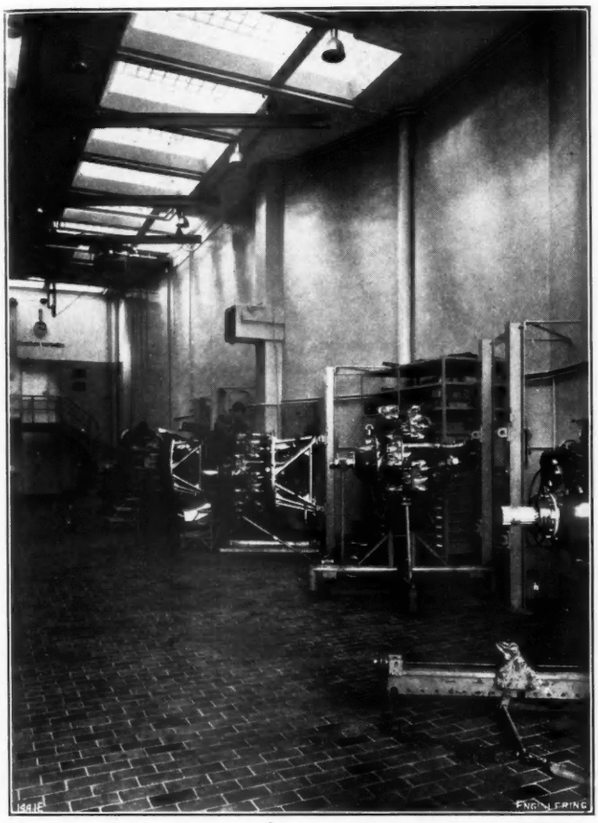


FIG. 7. PREPARATION ROOM.

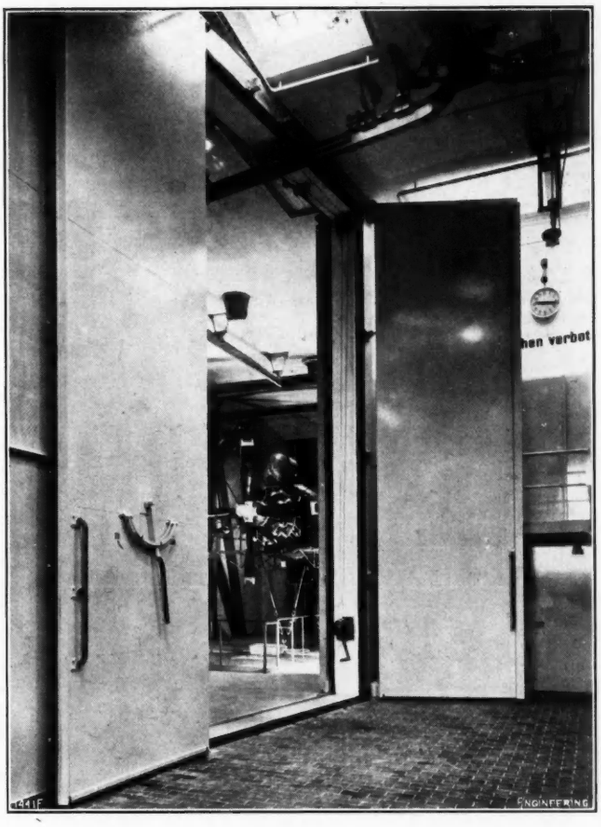


FIG. 8. SWING TRACK BETWEEN PREPARATION ROOM AND TEST CELL.

FIG. 9. ACOUSTIC SPLITTER PANELS.

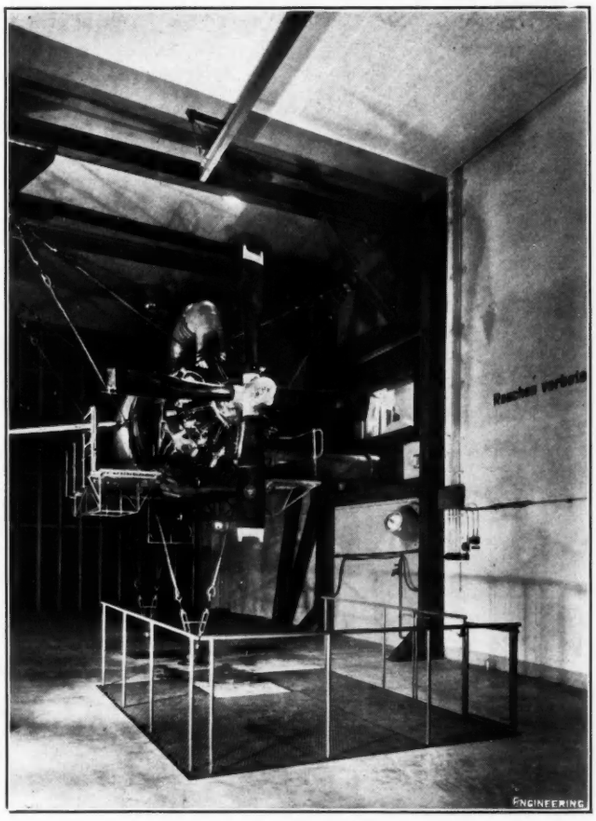


FIG. 10. ENGINE INSTALLED IN TEST CELL.

(*To face page* 772.)

self-explanatory—a welcome feature as the language of the text is not simple; there are many non-dictionary terms and some which have been coined for the purpose of the survey.

Précis de Physique Générale. IV. La Structure de la Matière.

By PROFESSOR ERNEST STAHEL. Bibliothèque Scientifique No. 24. Editions du Griffon, La Neuveville, Switzerland. [Price 15 Swiss francs.]

THE three previously published parts of this general course in physics covered mechanics, heat and electricity. The present volume, devoted to the structure of matter, is divided into three parts. The first traces the development of the atomic theory from its rise as a philosophical doctrine among the Greek thinkers to the mathematical methods of the kinetic theory for dealing statistically with assemblages of atoms or molecules. The main deductions from the kinetic theory as applied to ideal gases are simply derived and the connection between kinetic theory and thermodynamics is well brought out. The results of the more vigorous analysis are quoted for, as is pointed out, these usually only differ from the simpler deductions in the values of the numerical coefficients. After an indication of alternative means for determining Avogadro's number and an outline of the extension of the theory to real gases, applications of classical statistics to paramagnetism, metallic conduction and thermionic emission are considered, together with the anomalies which have necessitated the subsequent introduction of the Bose-Einstein and Fermi-Dirac statistics. Half way down page 15, $\frac{3}{2}$ should be replaced by $\frac{3}{8}$ and, on the bottom line of page 46, *el* should read *le*.

Evidence for the complexity of atoms is most directly revealed by spectroscopy and the next stage, consisting of investigations into the structure of the atoms themselves, is discussed in Part II. After explaining the reasons leading to the abandonment of attempts to interpret behaviour at the atomic level along classical lines, the Rutherford-Bohr compromise between classical and quantum views is described, together with the difficulties that have been largely removed by the advent of quantum mechanics. After presenting the experimental evidence for the dual nature of light and for the wave character of the elementary particles, the quantum theory of the hydrogen atom is discussed in some detail, together with the application of Pauli's exclusion principle to more complex atoms. This is followed by short chapters on X-rays, solid-state physics, molecules and molecular spectra.

The concluding section deals fairly fully with nuclear physics. Mention is first made of experimental methods for the detection of ionising and non-ionising particles and, after an account of the general properties of nuclei, methods for the production of protons, neutrons, positions and mesons are described and the reasons for the postulation of the neutrino are explained. The next two chapters outline the salient facts of natural radioactivity and the recent theories to account for the three types of radiation accompanying disintegration. Finally, a summary is given of the latest phase, ushered in with the first artificial transmutation of an atom by Rutherford in 1921, which has led to such spectacular developments in particle accelerators and the discovery of nuclear fission and artificial radioactivity. Particular care is taken to show how an energy balance-sheet for nuclear reactions is drawn up, and to indicate the more useful applications of such reaction.

Any attempt to expound so vast a subject in the course of 160 pages must obviously omit a good deal. Professor Stahel has focused attention on the guiding physical principles, illustrating their application, and indicating the relevant orders of magnitude, with representative numerical examples. The result is an exceptionally clearly written and logically arranged introduction to modern physics.

POWER JETS' GAS TURBINE PATENTS.—X.*

HEAT EXCHANGERS.

THE Power Jets' patent holding in regard to heat exchangers is relatively small and this is largely due, no doubt, to the fact that the original Power Jets Limited was concerned solely with the aeronautical field, in which, up to the present, no place has been found for the heat exchanger.

Patents relating to heat exchangers can be classified according to the types with which they are concerned, the two main types being (*a*) the recuperative, in which heat is transferred through a stationary wall separating the two fluids between which heat is to be exchanged and (*b*) the regenerative, in which a heat-storing matrix is alternately traversed by the hot and cold fluids so that heat is imparted to it by the one and taken from it by the other. Classification of the Power Jets' holding in this manner reveals a certain lack of balance as between the two types; this is again no doubt attributable to late entry into the field, work at the National Gas Turbine Establishment having been concentrated mainly on the regenerative type which, in its rotary form, appears to offer certain advantages in the gas-turbine field and has only in recent years attained a stage of development at all comparable to that of the recuperative type.

Chronology ordains that the patents relating to recuperators shall first be reviewed.

Recuperative Heat Exchangers.—Patent No. 607,717 relates to the tubular type of recuperator and is concerned with the uniform spacing of the tubes in a manner which is both simple and offers almost negligible obstruction to the flow of fluid between the tubes. The spacing is effected by arranging the tubes in bundles comprising tubes which have helical ribs provided around and along their outer surfaces and other tubes with plain outer surfaces arranged in a regular pattern among the ribbed tubes. The ribs may be formed as permanent excrescences on the tubes but the preferred arrangement is shown in Fig. 1, page 774, from which it will be seen that all the tubes are plain but that some (of which examples are indicated by the reference 2) are helically wound with wire indicated by the reference 3. The tubes are arranged in equi-angular pitching, that is to say in the form of a symmetrical bundle in which every tube is at the same distance from its immediately adjacent tube on every side, any one row (e.g., the four tubes marked A) being displaced transversely relative to the adjacent row (e.g., the five tubes B) by an amount equal to half the distance between the centres of adjacent tubes. In this particular arrangement, each ribbed (i.e., wire-wound) tube 2 is separated from the next ribbed tube in the same row by two un-ribbed tubes 1 and, as has been said, every tube is equally spaced from its neighbours. The wires offer but small resistance to fluid flow and can also act as additional heat-transfer surfaces.

The only other patent which has been selected for review in the recuperator section is No. 618,905 and this also relates to the tubular type. It is known that reduction of bulk and weight of heat exchangers, of both recuperative and regenerative types, is dependent in a large degree upon the use of passages of small cross section; the invention envisages the use of tubes of very small diameter (say, of the order of that of the needle of the hypodermic syringe as used by medical practitioners) and is primarily concerned with making the manufacture of such equipment possible. Fig. 2, page 774, shows a form which the heat exchanger might take, the minute tubes 1 being held in end-plates 2 of sintered powdered metal and the stack of tubes being supported within a casing having inlet and outlet connections 3*a* and 3*b* for the fluid which is to flow between the tubes. Several methods of making the tube and end-plate assembly are suggested in the patent specification; according to one of these, the end plates are compacted as "green" compacts in dies having core pins to form the holes required to receive the ends of the tubes; the tubes, held in a jig, are then inserted into the holes and the "green" compacts are placed in a furnace to sinter the compacts and fuse them to the tubes, which may be supported by fine internal wires during the process.

A patent relating to the cleaning of recuperative heat exchangers will be reviewed below in the next sub-section, since it is applicable also to the regenerative type and it is convenient to take it in conjunction with another patent which is applicable only to that type.

Regenerative Heat Exchangers.—Long before the rotary regenerator began to attract the attention of gas-turbine engineers, the type had been in use for waste-heat recovery in the steel industry and in the form well known as the Ljungstrom air pre-heater. When it came to be considered in connection with gas-turbine cycles, it became apparent that difficulties had to be overcome in connection with certain sources of inefficiency, from which the recuperator does not suffer and which were more or less negligible under the conditions of pressure differential encountered in the earlier uses of the rotary equipment. One of these sources was the loss of pressure from the high-pressure side occurring when a matrix cell passes from exposure to the high-pressure fluid (e.g., the cool compressed air in a gas-turbine cycle) to exposure to the low-pressure fluid (e.g., the hot gas flowing from the turbine) it is filled with fluid at the higher pressure and this fluid is lost to the low-pressure side of the system; this loss, known as the "carry-over" loss, is felt in wastage of work done in compressing the fluid. Furthermore, each cell, as it becomes first exposed to the high-pressure stream, is at the minimum pressure and some further pressure loss is suffered in filling the cell with fluid at the maximum pressure. A solution offered in the specification of patent No. 636,733 is illustrated by Fig. 3, page 774, in which a rotating matrix of drum type is indicated by the reference 1 and the low-pressure and high-pressure fluid ducts by the references 9 and 10; the ducts are sealed from each other by a partition 7, the ends of which engage the inner periphery of the drum with sealing contact as indicated at 11. In order to reduce carry-over loss, a passage 12 is formed in the partition to permit communication between pairs of cells as they respectively leave and enter the high-pressure zone (as at 13 and 14, respectively); in this way, the pressure in the two cells is equalised to a value intermediate between the high and low pressures obtaining in the system.

It is convenient here to take out of chronological order a somewhat later patent, No. 635,851, according to which the same principle is applied in a different construction of rotary regenerator. In this case, see Fig. 4, page 774, the regenerator comprises a pair of disc-like matrix members 1 and 2 co-operating with ducts 8*a*, 8*b*, 9*a* and 9*b*; cool air flows in the ducts 8*a* and 9*a* to pass through such matrix cells as happen to be in register with those ducts and escapes by way of the outlet 6*a* while hot gas flows from the inlet 7*a* to the ducts 8*b* and 9*b* by way of other cells. A pressure-sealing partition 5 is provided between the two discs and has internal passages 5*a*, whereby pressure-equalisation is effected in the same manner as before.

Published results of work done at the National Gas Turbine Establishment on rotary regenerators of the "flame-trap" type (i.e. having disc-like matrices with cells of triangular section formed by helical winding of alternate flat and corrugated-metal strip) indicate that such fouling as may arise in regenerators of that type used in con-

* Part IX appeared on page 743, *ante*.

junction with distillate fuels can be disposed of by means of a simple soot-blower; it remains to be seen whether this state of affairs will apply when other fuels are involved and when very small-passaged matrices of other types are employed. Of interest in this connection, therefore, are two patents which may conveniently be taken together, without regard to chronology, and which relate to the cleaning of heat-exchanger matrices.

The first of these two patents is No. 636,666, and the invention with which it is concerned is illustrated by Fig. 5. In the drawing, the reference 46 indicates a tapping from the turbine exhaust pipe 45 by which hot gases flow to the low-pressure side of the rotary regenerator 1; after traversing the matrix of the regenerator, the gases return to the exhaust pipe by way of a duct 47. The high-pressure side of the regenerator is in circuit between the compressor 41 and the combustion chamber 42; its rotor (matrix) is driven by a motor 50 through a variable-speed gear 49. Removal of deposited matter from the matrix cells is effected by the high temperature burning-off effect obtainable by driving the rotor at a much lower speed than usual (say, at one-twentieth normal speed); just as the matrix cells are raised to a relatively high temperature during slow rotation through the hot zone, so are they thoroughly cooled during the unusually long sojourn in the cold zone, with the result that differential contraction encourages the cracking off of any remaining deposit. The device indicated at 52 for controlling the variable-speed gear may be operated manually or automatically, for example by means of a clock, a revolution counter or a device sensitive to the degree of choking of the matrix cells.

Patent No. 640,978 is concerned primarily with the cleaning of the "hot" side of recuperative heat exchangers, but, inasmuch as the invention employs a burning-off technique akin to that of the patent reviewed above and could be applied to regenerative heat exchangers, it is convenient to review it here.

In this case, the burning-off effect is obtained by temporarily raising the temperature at the hot side of the exchanger to a value greater than the maximum permitted in operation; in order to avoid damage to the associated turbine in a gas-turbine plant, the rise in temperature must be confined to the part of the circuit downstream of that component. The higher temperature may be achieved by means of a supplementary combustion chamber connected, either in series or in parallel, between the last turbine stage and the heat exchanger, or valves may be provided to enable the main combustion system of a gas-turbine plant to be employed for the purpose; the latter arrangement is illustrated by the diagram reproduced as Fig. 6, opposite. In normal operation, the four two-way valves 11, 12, 13 and 14 are set so that air delivered by the compressor 1 and pre-heated by passage through the cold side of the heat exchanger 5 passes through the combustion chamber 4 to the turbine 2, and thence to the hot side of the exchanger and exhaust, all as indicated by arrows. When burning-off is required, the valves are set so that, instead of being connected in series upstream of the turbine, the combustion chamber is similarly connected downstream of the turbine so that all combustion takes place between the turbine and the heat exchanger; an interlinked control (not indicated in the diagram) is provided to increase the supply of fuel to the combustion chamber as required to attain the increased temperature for burning-off. In any of the alternative arrangements mentioned, the attainment of the requisite high temperature may be facilitated by the supply of oxygen to the heat-exchanger passages or by the employment of a catalyst.

Since the stress sustained by heat-exchanger walls is dependent on the pressure difference as well as on the temperature of the material, it is preferable to reduce this difference during burning-off; this may be achieved either by providing a path by which the high-pressure fluid can by-pass the cold side of the heat exchanger or by the provision of an auxiliary motor (indicated at 6 in Fig. 6, opposite) by which the rotary components can be turned at a speed below the self-driving speed during the cleaning operation.

The next patent, No. 665,099, is concerned with a mechanical problem, namely, that of keeping the bearings of a rotary regenerator away from the hottest fluid. As illustrated in Fig. 7, opposite, two matrix discs 19 and 20 are employed and the casing is divided into three chambers, of which each is sub-divided into two by a diametrical sealing member indicated generally by the reference 34. Cool fluid enters the casing by the inlets 11 and 12, and, after passing through the matrices to the central, upper half chamber, escapes by way of the single outlet 13. The hot fluid enters the central, lower half chamber by the inlet 14 and passes outwards through the matrices to escape by way of the outlets 15 and 16. By this arrangement, it will be seen that the bearings 22 and 23 of the matrix rotor are situated as far as possible from the hottest fluid entering by way of the central inlet 14. The fluid streams passing nearest to the bearings are respectively the coldest streams which have not traversed the matrices at all and the streams of fluid which have been cooled by passage through the matrices.

Also concerned with the protection of rotor bearings is patent No. 645,417; the arrangement concerned can be simply explained by reference to the sectional drawing of Fig. 8, opposite. In this case, the matrix is in the form of a drum 1*a*, through which the fluid passes in the radial sense; a diagonal sealing partition 3 is provided to separate the flow paths and the arrangement is such that the colder fluid follows the path indicated by the arrow 4 and the hotter fluid that indicated by the arrow 5. The bearings 2 are situated well away from the hotter fluid and the only paths for the transfer of heat to them are provided by the relatively thin, concentric annular supports 7 and 10.

POWER JETS' GAS-TURBINE PATENTS.

Fig. 1.

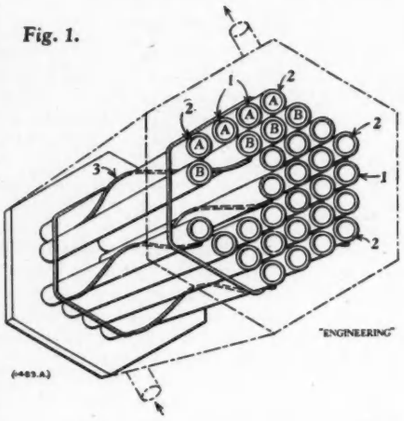


Fig. 2.

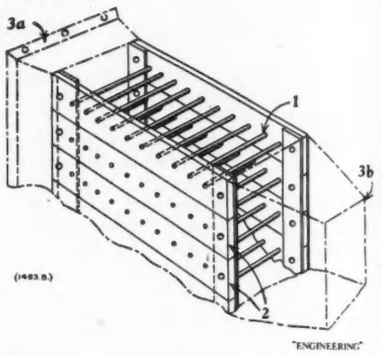


Fig. 3.

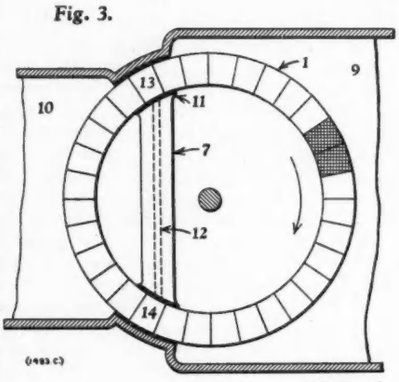


Fig. 4.

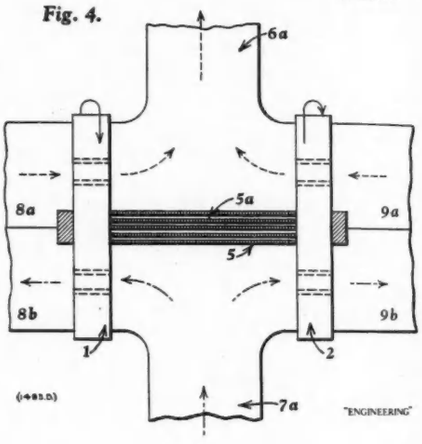
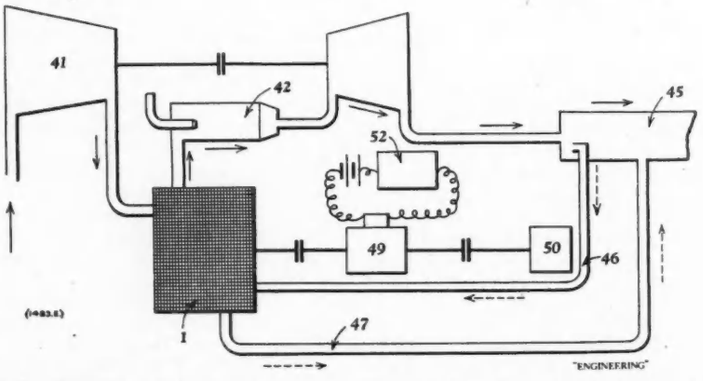


Fig. 5.



POWER JETS' GAS-TURBINE PATENTS.

Fig. 6.

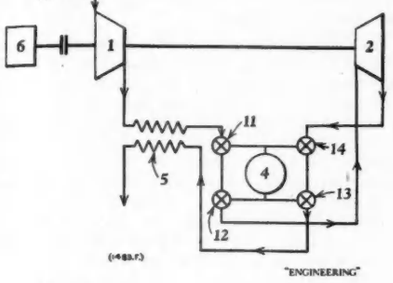


Fig. 7.

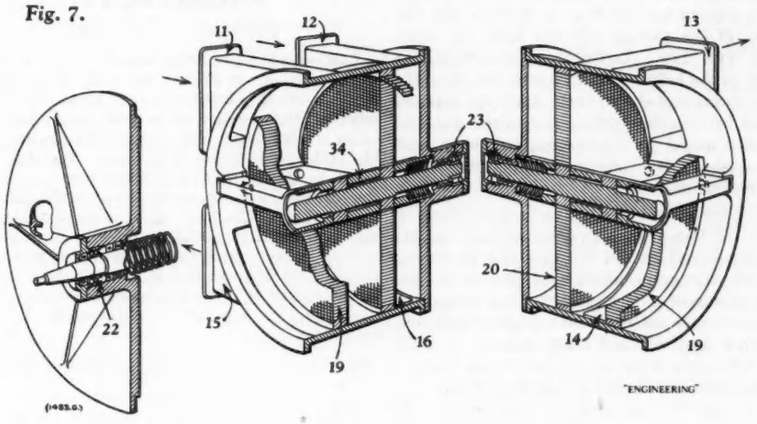


Fig. 8.

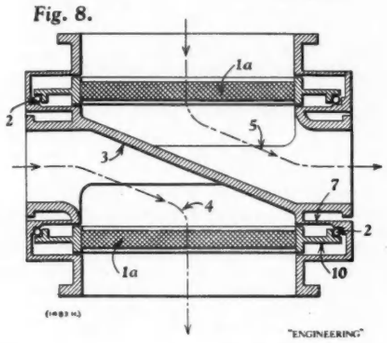


Fig. 9.

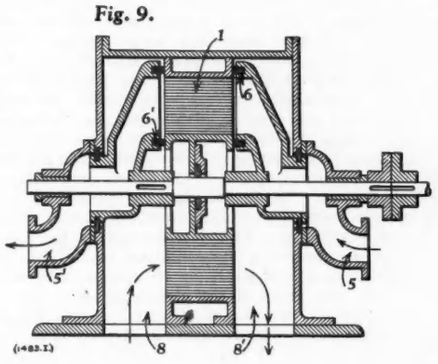


Fig. 10.

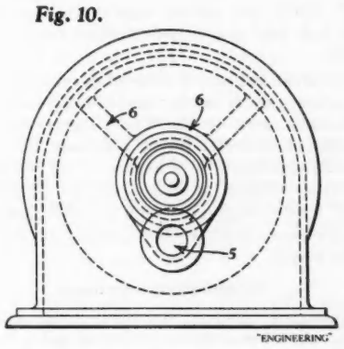


Fig. 11.

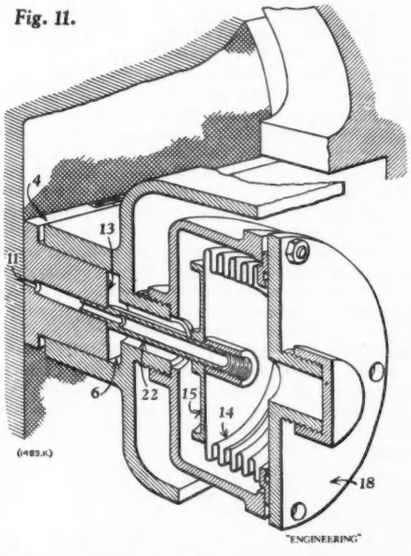
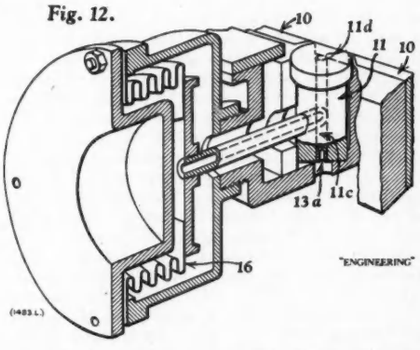


Fig. 12.



The satisfactory development of a rotary regenerator depends upon the solution of the problems set by two sources of pressure loss. This sub-section opened with reviews of patents concerned with expedients calculated to reduce loss from one of these two sources, namely, that known as carry-over loss; it is, perhaps, fitting that the sub-section should close with reviews of patents concerned with the solution of the other and more serious problem due to loss incurred by leakage across the seals provided at the matrix faces to separate the high- and low-pressure zones from each other.

The first of these patents, No. 683,282, is one of several under which Power Jets has obtained licensing rights from one of its "outside" consultants, George Jendrassik, who successfully ran a 100-h.p. gas turbine before the last war. The invention with which this particular patent is concerned is illustrated by Figs. 9 and 10, which represent, respectively, a longitudinal section through and an end elevation of a rotary regenerator. The matrix 1 of disc form is traversed by high-pressure fluid entering by the inlet 5 and leaving by the exit 5′ and by low-pressure fluid entering and leaving at 8 and 8′, respectively. The high- and low-pressure streams are separated from each other by sealing partitions 6 and 6′, which are resiliently pressed against the opposite faces of the matrix; as is indicated by dotted lines in Fig. 10, the sealing partitions are each in the form of a closed figure which defines the path, at the matrix face, for the high-pressure fluid. The width of the partitions is so related to the dimensions of the cells in the matrix that a cell registering with a sealing partition is shut off from both fluid streams.

In cases in which a sealing element is in contact with a matrix face, the necessarily discontinuous nature of the latter must inevitably present a problem connected with wear of the element; furthermore, excessive contact pressure will exercise a braking effect on the matrix, with consequent undesirable power consumption. It is possible, in some installations, for contact pressure to be unintentionally increased by the effect of the leakage of high-pressure fluid to a position behind the element, from which it can exert a superfluous force urging the element towards the matrix. The fragmentary sectional view of Fig. 11 illustrates the subject of Patent No. 687,103, which is concerned with this problem. In this case, the sealing elements 4 are pressed toward the matrix by the action of pressure fluid tapped off from the cells of the matrix by way of slits in the faces of the elements and passed to bellows (or the equivalent) of which one is provided for each separate element. As shown in the drawing, each slit 11 communicates with the associated bellows 14 by way of a hole through the element and a stepped tube 22, which is screwed into the front plate 15 of the bellows. The back plate 18 of the bellows is anchored and the step on the tube 22 abuts against the rear face of the element; the latter is thus urged towards the matrix with a force proportional to the pressure obtaining at the entrance to the slit 11, this force being that calculated as necessary to offset the force which the fluid pressure exerts on the working face of the sealing element, tending to push it out of contact with the matrix. The tube 22 passes with adequate clearance through a hole in a fixed member 6 and the rear face 13 of the sealing element is made equal in area to the face of the front plate 15 of the bellows; thus, any high-pressure leakage fluid which finds its way behind the sealing element exerts equal and opposite forces on the sealing element and the free face of the bellows and is thus unable to affect the force with which the latter urges the element toward the matrix.

A more recent patent application, which is still pending, relates to an improved form of seal developed from that illustrated by Fig. 11. In this case, as shown by Fig. 12, a bellows 16 (which forms one of many, as in the previous case) communicates with a bore 11c in a pivot pin 11 provided between adjacent sealing elements 10; one end of the bore communicates with a passage 11d, which leads to an opening in a flattened face of an enlargement of the pivot pin and adjacent the high-pressure edge of the seal; a small leak orifice 13a

is provided at the other end of the bore, communicating with the low-pressure zone. In normal operation, high-pressure fluid leaking past the high-pressure edge of the seal finds its way into the bore by way of the passage 11*d* and leaks out again at the same rate; under these conditions, the pressure in the bellows, together with the effect of a loading spring (not shown in the drawing), balances the fluid load on the working face of the seal with the latter spaced at a predetermined, very small distance (say, a few thousandths of an inch) from the face of the matrix.

If the clearance between seal and matrix increases, the rate of leak-in of high-pressure fluid via 11*d* will increase and exceed the rate of leak-out via 13*a*; the temporary increase of pressure in the bellows thereupon acts to push the seal toward the matrix to reduce the clearance. Seals of this type, in which a predetermined small clearance is maintained between seal and matrix with a corresponding continuous small leakage of fluid from high-pressure zone to low-pressure zone across the face of the seal, are known as "leakage seals"; they benefit over contact seals by the avoidance of seal-face wear and of braking-effect on the matrix rotor.

Since the last patent application reviewed relates to a late stage in the National Gas Turbine Establishment's work on the rotary regenerator, it is significant that Mr. Hayne Constant, Director of the Establishment, in a lecture to the North East Coast Institution of Engineers and Shipbuilders (see ENGINEERING, January 9, 1953, page 61), expressed his belief that the sealing problem had been solved.

AUTOMATIC GREASE LUBRICATOR.—A grease lubricator which has a capacity of 1¼ oz. and is suitable for fitting to bearing housings in place of grease nipples or on plant that requires positive and permanent lubrication, but does not warrant the use of a mechanical lubrication system, has been made by Trier Brothers, Ltd., Cumberland Works, Caldew-street, Camberwell, London, S.E.5. The "Central Gun-Fill Lubricator" is designed to be filled with a grease gun through a centrally placed nipple. It comprises a barrel with a plunger mounted on a hollow rod with the filling nipple at one end. A spring behind the plunger maintains a steady pressure on the grease contained in the barrel, and feeds the grease to the bearing, while a screw which enters into the feed channel of the nozzle enables regulation of the rate of feed to be made. The hollow rod of the plunger moves into the barrel as the grease is discharged and acts as a "tell-tale" type of indicator. The shank for attaching the lubricator to the bearing housing is screwed ¼ in. British Standard pipe thread. The company state that they intend to produce a 3-oz. model in the near future.

WELDED ALUMINIUM TIPPING LORRY.—After eighteen months of service with the North Thames Gas Board, an aluminium truck body of a tipping vehicle which is being tested by them was inspected and appeared to be in better condition than the steel bodies that are usually used for the same class of work. The loads carried by this vehicle were coke and breeze, the corrosive and abrasive nature of which causes such rapid deterioration of steel bodies that they require reflooring at least once a year and usually have to be scrapped completely after three years of service. This aluminium body, however, was still in good condition after the eighteen months, and measurement showed that there had been little reduction in the thickness of the metal in the sides and the floor at the points of maximum wear. The success of the body is considered to be due to its resistance to corrosion and to the fact that the welded joints leave no crevices from which failure might begin. It is also claimed that the body has a lower maintenance cost. Development of the body was undertaken by Anthony Hoists, Ltd., Braintree-road, South Ruislip, Middlesex, in collaboration with the Northern Aluminium Co., Ltd., Banbury, Oxfordshire. The alloys used were Noral M 57 S for the sheet and plate, and 51 S for the extruded sections. The tipper body is believed to be the first body employing welded construction throughout that has been made in this country, and it is claimed as a typical example of modern techniques in aluminium welding.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 732.)

THE concluding technical session, which was held in the afternoon of Friday, March 27, of the Spring Meeting of the Institution of Naval Architects followed the practice of several recent years in being a joint event, arranged in collaboration with the Institute of Marine Engineers. The chair was taken by Mr. R. Cook, a member of the Council of the Institute, who was accompanied on the platform by Mr. Lloyd Woollard, M.A., a vice-president of the Institution of Naval Architects. Two papers were presented during the afternoon, the first being by Mr. J. D. Farmer, O.B.E., and Mr. K. C. Hales, on the subject of "The Insulation of a Refrigerated Cargo Ship." A summary of the paper is given below.

THE INSULATION OF A REFRIGERATED CARGO SHIP.

In essence, the paper extended and brought up to date a survey of the factors affecting the construction of insulated cargo holds, and of the leakage of heat from such cargo spaces, which Mr. Farmer, jointly with Mr. A. J. M. Smith, read before the Institution of Naval Architects in 1934.* Since that date, the present paper pointed out, there had been considerable advances in the technique of marine refrigeration and, in some respects, changes in the practice of insulation. The method of cooling cargo spaces by the forced circulation of air through a battery of pipes, as opposed to convective cooling, had added greatly to the refrigeration power load. The total demand on the refrigerating machinery was considered in the light of the thicknesses of insulation on various surfaces in a ship, the effect of the insulation on the cargo capacity and the deadweight capacity, the means of minimising condensation, the disposition of the insulation, etc. Though, at present, no suitable insulating material was available which possessed a lower thermal conductivity than those commonly in use, the authors indicated the possible savings in capacity, should such a material be found. In calculating the estimated heat leakage for a particular design, it was necessary in practice to allow a margin for deficiencies in the construction of the insulation and the performance of the refrigerating machinery. The most common causes of excessive heat leakage were by the exchange of air between the inside and the outside of the cargo space, and by air movement through the body of the insulation. Methods of measuring the performance of the refrigerating equipment and of the insulation were discussed, and the results of measurements on typical ships were quoted. These, the authors observed, suggested that, in some cases, the actual heat leakage could be considerably in excess of the estimated figure, though, in practice, there was usually a fair agreement between the measured and the estimated leakage.

DISCUSSION.

The discussion was opened by Mr. H. R. Howells, who said that he was in general agreement with the authors. As regards the basic conductivity figure for insulating material, used in all the calculations, namely, 0·27 B.Th.U. per square foot per hour per deg. F. per inch of thickness, he emphasised the necessity for a margin. He was glad that the authors had included some information on air circulation; its effect on the temperature range was often overlooked. There was also a section dealing with the effect of position and shape of space on insulation, and it included a table showing the heat leakage in relation to the volume. That, of course, would apply only when all the spaces were refrigerated, or when, at least, the adjacent spaces were refrigerated. The lower holds showed up well on account of their greater depth. With regard to the results of performance measurements by inspection of the ships' logs, measurements and estimations of heat leakage, he stressed the necessity for a careful reading of the authors' remarks in that section. The estimated figures were probably very good estimates, but a number of factors came into the calculated figures which were not absolute fact. The operation of the plant might cause a large alteration in the figures.

Mr. John Baird said that the paper provided a very good answer to questions raised by Mr. Basil Sanderson, in his paper to the Institution in 1952, regarding the amount of space occupied by insulation; but it went much farther in investigating the general question, and showed that the proposals made in the 1934 paper by Mr. Farmer and Mr. Smith had, in fact, been adopted in the modern cargo liner. It must be a matter for considerable satisfaction to Mr. Farmer that his earlier work had borne fruit. The problem was simply stated in the introduction, where it was said that, "Short of actual improvements in insulating materials or methods of insulation, the less the space occupied by insulation the more will be needed by the cooling system." The paper indicated how an economic balance between those two factors could be attained. On the whole, and as a result of the investigations made, the present practice in thicknesses of insulation was justified, but attention was rightly drawn to one or two outstanding weaknesses. The paper indicated that about 14 per cent. of the heat leakage into cargo spaces was through hatch plugs and coamings; they occupied an area of about 12 per cent. of the overheading, and yet the heat leakage from the overheading was very little more than from the hatch. That lent force to the authors' statement that attention must be paid to the method of insulating hatches. It would appear that, if the hatch could be designed in steel, with similar characteristics to those of the overhead deck, that problem might be solved, but it was complicated by stevedoring requirements and a balance would have to be struck between those factors. A study of the paper also indicated that it was doubtful whether the cost of insulating the top of the floors in insulated lockers was justified, but at least more expense might be incurred in the overheading insulation and less on the floor, with no loss of accurate temperature control. The authors also drew attention to the question of insulating both sides of terminal bulkheads, but, while their proposal to restrict the insulation on the non-stiffener side to circumferential ribands was probably worth while from the point of view of cost, the necessary dunnaging required on the bulkhead would prevent any addition to the capacity. The authors suggested that any improvement in the thermal conductivity of insulating materials could be utilised to provide increased capacity. It could also be used to retain the existing thicknesses, to increase refrigerating performance; but a reference in the paper appeared to indicate that the correct method was to reduce insulation thickness.

Mr. G. Laing observed that, as indicated by the authors, the thermal conductivity of insulation material was a basic assumption of the calculations, and the figure of 0·27 B.Th.U. per square foot per hour per deg. F. per inch had been used as fairly representative of the materials at present used. The authors mentioned two materials usually employed, namely, glass fibre and granulated cork. As far as could be ascertained from independent sources, such as the National Physical Laboratory, lectures by Dr. Ezer Griffiths, and the Codes of Practice on Refrigeration issued by the British Standards Institution, the former material had a thermal conductivity value of 0·22 to 0·23 and the latter, 0·29 to 0·31. Neither of those figures should be used in calculations, for they were obtained under ideal conditions; a factor of 15 to 20 per cent. should be added to give a practical figure. That would make the figure of 0·27 suitable for glass-fibre calculations, but rather underestimated the granulated-cork figure, which would be in the region of 0·34 to 0·35.

The paper stated it to be common practice to increase the insulation temporarily by a layer of sawdust; in his opinion, that was unsound, and aggravated the condensation problem. Any intermediate insulation must be properly sealed to prevent the entry of moisture; if moisture entered the insulation, it destroyed the insulating value.

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* "Structure of Insulated Holds in Relation to Heat Leakage," *Trans. I.N.A.*, vol. 76, page 52 (1934).

He agreed with the authors' remarks on the serious heat leakage at hatch plugs. The heat leakage at hatches was 6·7 per cent. of the total refrigerating demand, and approximately 14 per cent. of the total heat leakage, in a fully-refrigerated ship. If there was an insulated 'tween deck only, with plug hatches above and below, the figure would reach approximately 30 to 35 per cent. of the total heat leakage. Experiments were being made with a reinforced-plastic hatch plug which combined lightness with rigidity and would have a considerably higher insulation value. The material would also with stand very high impact. The figure of heat leakage along brine leads was given as 45,000 B.Th.U. per hour. If the brine leads were assumed to be in a box of 4 ft. by 2 ft. cross-section and having a length of 200 ft., that represented a heat leakage of 0·25 B.Th.U. per square foot per hour per deg. F., which was equivalent to a thickness of insulation of only 1 in. Since brine leads usually had insulation 4 in. to 6 in. thick, there could be only two possible explanations: either the authors had over-estimated the leakage or the insulation was completely inefficient. The latter explanation was very probable, since it was usually considered sufficient to insulate the brine leads in a similar fashion to the insulated holds. There was a world of difference between the two cases, however, since, in the case of brine leads, the coldest spot was in the centre of the insulation and not on one side of it; that introduced the question of continuous vapour penetration, which arose only intermittently, if at all, on the general insulation. It was possible, where the material used on brine leads was such as to absorb moisture, that vapour was soaked up by the material, destroying five-sixths of its insulation value.

Mr. S. J. Duly said that it must be a source of satisfaction to the authors to have prepared and presented such a fundamental paper. All would appreciate the value of the continuity of the work begun 20 years ago by Mr. Farmer and the late Dr. Smith. He had studied the paper with interest, more especially in order to assess the effect, if any, of the insulation becoming damp. The flow of heat through the insulation on board the ship discussed by the authors amounted to 502,000 B.Th.U. per hour for 600,000 cub. ft. of insulated space, under the conditions stated. In arriving at that total, the conductivity of the insulating material was taken as 0·27 B.Th.U. in the customary dimensions. That would be for dry insulation; but it might not remain dry. Hydroscopic moisture would have little effect on the insulating power of the material, but possible accumulations of free water might easily double the conductivity. He had measured (by analysis) the moisture in 14 samples of granulated cork from a cold store on shore, which had been in use for some time, and in eight samples there was between 50 and 110 per cent. of water, based on the dry weight of the cork. That would more than double the amount of heat flowing through the walls from the outside. The safety factor allowed on board ship, by providing thicker insulation than was necessary theoretically, might be reduced if the assumption could safely be made that the insulation would remain in its original dry state. The conditions leading to the condensation of moisture within insulation had been investigated at Stockholm by Carl Munters, who had evolved a process to maintain insulation permanently in its original dry condition. In marine practice, the process had had its most notable success in Germany, where, over the past two years, eight fully-refrigerated ships had their insulation maintained in a dry condition by that means. The provision rooms in 60 vessels in service and under construction had the insulation similarly protected by the method of de-humidification. He understood that, in the case of the eight German ships, a saving of 5 per cent. of the total capacity was effected, as the designers could depend on maintaining minimum conductivity. He invited the opinion of the authors on the reduction in thickness, and the improved efficiency, of insulation which might result from the assurance that it would remain dry.

Mr. O. Bartlett observed that, in Table VI of the paper, the loss from evaporator rooms (which presumably included brine-control rooms) was shown as 75,000 B.Th.U. per hour. He asked whether the brine-control room was an integral part of the evaporator room, and whether the calculation took into consideration the opening and closing of the entry door. The losses that he had mentioned amounted to slightly more than those attributed to hatch plugs and coamings—actually, 0·6 per cent. The authors stated that much more could be done to improve the design of insulated plugs and doors. Designers of insulation were trying, in fact, to evolve a better type of door, especially for the cooler entry, which, as stated, could be an alarming source of leakage. A structural saving could be effected by decreasing the number of separate hatch plugs to a row, as had been done on some of his company's recent vessels. The losses in the evaporator room, shown in the paper, seemed high, and some method of reducing them might be devised. It would be interesting to know how much heat was lost whenever a door was opened for entry. It was common practice to fit an air lock, but how often it was used was a matter for conjecture. A modern ship with many compartments, carrying a variety of cargoes, required many entries to be made for the observation of brine temperatures, cock control and de-frosting, though they had been considerably reduced in number by fitting injection controls, coupled with long-distance radial thermometers outside the room. It would be interesting, too, to know the difference in heat loss in a vessel where the evaporation room was completely isolated from the control room (where entry was occasional) as compared with one where the evaporation and brine rooms were in common. A good deal of heat loss would be avoided by insulating evaporators and brine mains, but would the added cost and the inconvenience when executing repairs and special surveys be justified? He agreed with Mr. Laing that 4 in. to 6 in. of insulation for brine leads was not enough; it should be in the vicinity of 8 in. in some cases.

Dr. H. Stafford Hatfield said that, towards the end of the war, he had developed, for the Admiralty, means for measuring heat flow in ships. These were applied to examining why the extensive cold rooms installed on large ships such as H.M.S. Vanguard gave such poor performance when tested for insulation by heat input. In contrast to conditions in the refrigerated cargo ship, nothing stood in the way of giving such rooms a thorough and exact test, which had been done for many years by measuring the heat input necessary to maintain such a room at a steady temperature. From those figures, an "overall k value" could be calculated—the apparent thermal conductivity of the walls of the room. If the walls were plane surfaces, covered everywhere with insulation of uniform thickness, the k value would approximate to that of the insulation material used, as tested in the laboratory. Everywhere, however, there were frames, beams or stiffeners, and heat leakage through grounds, meat-hooks, etc., which were allowed for according to the well-known rules; but no liberality in that allowance resulted in more than half the k value actually observed. In fact, it was found that rooms insulated with aluminium foil gave an overall k value of about 1 in British units, while the foil measured in the laboratory gave 0·25 or less. Mr. Hales's assumed value of 0·27 seemed too low for fibre-glass or cork.

Still more shocking to naval engineers was the fact that poor insulation sometimes deteriorated grossly after a few years in service. The heat-flow meters provided a detailed picture of the flow of heat through the walls, showing that the poor results were due to bad installation, local corrosion and water condensation. They had supposed that the heat-flow meters would be received as a boon by those responsible for testing refrigerated cargo ships, but they were soon undeceived. As Mr. Hales pointed out, the time required for such tests made them uncommercial. A few of the meters might have enabled him to check one or two doubtful points in the estimation methods. An extensive series of experiments was made on models of various typical steel structures, estimating the effect of insulating them by the electrical capacity method. As was well known, the electrostatic capacity between two more or less parallel surfaces of electrically conducting material in air was proportional to the heat which would be conducted through a solid insulator filling the space between them, because the lines of electrostatic force had exactly the same shape as the lines of heat flow. The Admiralty liked methods of detecting bad work on the part of contractors, and there the detailed disc test was useful, because bad installation was in patches. Did the ships mentioned in the paper undergo Lloyd's warming-up test? It had no great value, except in comparing identical installations, as it depended upon the heating-up of the insulation, which had a far greater thermal capacity than the air in the holds. The thermal capacity of different forms of insulation varied greatly and, indeed, was the less, the better the insulant; so that Lloyd's test might give a picture which was the opposite of the truth. Waterlogging, the greatest of all troubles, raised the thermal capacity and diminished the insulation value greatly, and so favoured Lloyd's test. Was that test applied to ships after they had been in service for some time?

Professor E. V. Telfer said that he would like to see in the paper some information about the weights of the machinery and the insulation involved. It was significant that such important items as the weight, and what it had cost the ship designer to give the shipowner an insulated ship, were entirely missing from the paper. If the authors could include such information, naval architects would be grateful.

Mr. S. J. Jones commented on the stress which the authors placed on the effect of the stiffeners and beams on the overall effectiveness of insulation. Faulty insulation round such structural members could, and did, cause not only severe losses by heat transfer, but often considerable nuisance value and expense in dealing with the problem of condensation on the other side of the bulkhead. They also rightly stressed the necessity for high-grade workmanship in the application of insulation; he had measured conductance figures which were more than 100 per cent. greater than was estimated, due to bad application during the war years, when only inexperienced labour was available. One such case, while not directly connected with a refrigerated cargo space, served as a pointer on matters of insulation. Cool air at about 45 deg. F. passed through a duct, led through the deck. The duct was insulated carefully above and below the deck, but a strength coaming was welded into the deck and the trunk was attached to it, generating a cold spot in the vicinity. In tropical and sub-tropical waters, when temperatures and humidities rose, condensation on the deck and the vertical bulkhead was such that it was quite common to have about 6 in. of water underneath a bunk at the ship's side. Obviously, the cold-air duct should have passed through the coaming, with a suitable gap between it and the coaming itself, filled with a suitable insulating material. However, that was not done, and the problem of preventing condensation arose. If insulation were applied to the portions where condensation was shown to exist, the cold bulkheads and deck were protected by a layer of insulation and the cold travelled farther along; therefore, condensation occurred at some other point, farther away, until such time as a balance was obtained. That point was often overlooked, and if insulation was to be applied at all, obviously it must extend over a much larger area than the initial area showing condensation. He invited the authors' views on how best to attack such a problem. Another case dealt with the condensate drains from the cooling-coil units in refrigerated cargo spaces. In many instances, some fresh air was introduced; consequently, moisture condensed on the brine coils, and normally was drained away beneath. That was another source of trouble, because so often little care was taken in avoiding metallic contact between the drain and the deck below, with the result again that condensation occurred on the deckhead below, and, in some cases, damage to cargoes in the hold.

The authors mentioned the considerable fan-power required to maintain even conditions within the refrigerated space. That factor was always present, because, if an even temperature was required throughout such a space, the quantity of air handled was a function of the rise in tempera-

ture which was allowable. That, in turn, was bound up with the actual heat transmission or heat loss through the boundary walls. Obviously, therefore, the more efficient the insulation and the bigger the range of temperature allowable in the space, the less was the fan-power required; and, as stated, it would vary from one cargo to another. A very important assumption was made by the authors in computing the total refrigerating demand for a ship. It had been assumed, when making the calculations, that the power required by the fans was proportional to the volume of air to be circulated, i.e., in all cases, the fans were working against the same pressure. That was true; but generally there was a fixed duct system, in which case the power would vary as the cube of the air volume handled. The space occupied by the equipment, together with the insulation, was compared with total cargo stowage available, and it was suggested that new materials might provide lower conductance values than those available at present. He wondered whether something might be learned from the aircraft industry and a construction adopted, at least in the vicinity of the refrigerated holds, which would not need such deep and heavy stiffening and, consequently, such heavy insulation as was necessary at present.

Mr. W. F. Cooper said that many modern ships did not experience moisture in the insulation; probably because, when such a ship was carrying refrigerated cargo she was looked after, and, when carrying general cargo, not refrigerated, the installation was run as an air-drying plant. Ships' officers should be taught the simple theory of ventilation; if they were taught the use of a hydrometer, they would have no more difficulty with condensation.

Mr. Farmer, replying to the discussion, said that, for 20 years, he had been writing papers on the behaviour of and the factors behind insulation. He and his colleagues had experimented with ships and had made heat-balance tests, and, from time to time, had encountered ships which gave very bad results in practice. It seemed extraordinary that insulation contractors so seldom used the term "British thermal units" in any conversation. It was about time that, when buying insulation, the contractor could be asked how much it would cost and weigh, and how much heat would escape. It was astounding that, until comparatively recently, except in connection with cold stores on land, there was no mention of moisture in insulation. In some installations in ships, they had found moisture due to broken pipes, in certain parts of provision rooms and in way of brine leads, etc.; yet there were insulated ships, up to 40 years old, in which no moisture was found in the insulation. In reply to Professor Telfer, it was difficult to give a formula for weights of machinery and insulation related to cubic capacity. An isolated 'tween deck might need more insulation than a big ship. It was about time that something more sensible was done about hatch plugs and doors; they were so big and heavy that they defeated their object as insulators and in making spaces airtight. The problem would be easier if they were not so heavy and susceptible to distortion.

Mr. Hales, who also replied, thought that, with regard to thermal conductivity, something would develop in the near future. It should be discussed properly by the people interested before anything was published, although many of the figures were available already. He added that he and Mr. Farmer would reply to other questions in writing.

(To be continued.)

THE ROBERT WARNER FELLOWSHIP IN FOUNDING.—The Worshipful Company of Founders, 13, St. Swithin's-lane, London, E.C.4, administer a Trust Fund left by their former Master, the late Mr. Robert Warner, for providing a Fellowship to foster research applied to foundry practice. The first award has been made to Mr. John Henry Gittus, B.Sc., a member of the research staff of the British Cast Iron Research Association. The holder will continue with his present work and carry out the Fellowship programme on a part-time basis, on the related subjects of mould erosion by the molten metal and the effect of mould conditions on the surface finish of the casting. The work will be supervised by the Association's research manager, Mr. H. Morrogh.

PRESIDENTIAL ADDRESS TO THE INSTITUTE OF BRITISH FOUNDRYMEN.*

By E. LONGDEN, M.I.Mech.E.

IT is of the first importance for an Institute, as for an individual, occasionally to take stock of the present position and possible future developments, or trends. The principal progression over the past 20 years has involved the steady but firm shift of emphasis from the purely practical work and art of founding to the scientific, technical and engineering aspects of casting manufacture. The membership of the Institute is diverse in its make-up, and the variety of its interests and problems would appear to be greater than those of other technical bodies catering for the needs of industry. We see operating the collective efforts of an excellent cross-section of scientific and technical workers, ranging from highly skilled craftsmen to the most eminent of scientists.

There is a great accumulation of scientific knowledge much of which is not being used correctly, or at all, by the operative craftsman. On the other hand, there is failure on the part of certain scientists to understand production procedure and the parochial-mindedness of manual employees. In imparting a better understanding of either old or new knowledge, simplicity in expression and arrangement will yield the most speedy and satisfactory results.

The meaning of technology and science is more broadly and more frequently defined than that of craftsmanship. The term "craftsmanship" should mean the skills which are exercised in the production of anything that is necessary for the well-being of a people. The fulfilment of our aims, or needs, can only be accomplished by the use of suitable materials, in the manipulation of which we employ art and skills. In this there is the need for knowledge of the make-up of materials, for creative faculties, resourcefulness and general technical understanding.

During the past two decades there has been a great awakening to the efficient training of scientific and technological leaders. Modern educational facilities are adequate to the needs, and an excellent flow of informed men is now being felt. I am sure that we in this Institute have always had the greatest admiration for those who, without the advantages of a university or technical-college education, have acquired a knowledge of the scientific aspects of foundry metallurgy and foundry technique which compares favourably with that of those who have had a more classical education. It is a quality of education which demands great energy and resourcefulness, that is so frequently absent in many who have had studies made convenient and easy. Thus, when we pause to take stock, we realise that we are rich in the collective experience of many trained minds. They are endeavouring to leave as little as possible to chance, although chance may occasionally yield solutions, as well we know from discoveries such as penicillin. I believe it was Pasteur who said "chance favours the prepared mind."

In retrospect, there is every reason to find satisfaction in the recorded work of the Institute's Technical Council which, with its technical subcommittees, has poured out a great volume of reliable foundry technical literature, based on the investigations and experience of technological experts. These men, selected from various parts of Britain, are making considerable contributions to the store of foundry technical knowledge, gained from close contacts with the realities of casting manufacture. This work is of a voluntary nature and cannot be done effectively without painstaking efforts and actual sacrifice of normal leisure. Members of the Technical Council and its subcommittees are largely responsible officials of industrial firms of national and international repute, along with certain representatives of the cast-metals research associations. These enlightened industrial firms are the first to feel the benefits from any scientific and technological research probe or effort. They also realise that they are not only helping themselves, through active representatives, but, indeed, contributing to the general pool of knowledge for the benefit of the foundry industry.

Since the activities of the Technical Committee (subsequently, in 1946, renamed the Technical Council) started in 1930, investigation and research have covered many representative phases of foundry technique. The result of the work has been recorded in some 36 valuable reports. At the present time, there are some 15 separate investigations in progress on various phases of ferrous and non-ferrous foundry metallurgy and practice. This work is spread over some 150 selected technologists. From its inception, the activities of the Technical Committee and, later, the Technical Council have been ably directed by its successive chairmen, namely: Messrs. J. W. Gardom, P. A. Russell, and A. E. Peace, the present chairman, who has held the office for many years.

This co-ordinated effort of the collective experience of experts in all branches of foundry work sets a standard which might well be emulated by the classical research organisations. A parent research organisation of cast metals can be envisaged, the object being: a unification of research into the common problems of cast metals and their economic fashioning into castings. There has always appeared to be a common basis of approach from the research level through its technological interpretation right down to its application at the production levels, for all cast metals. We are all too familiar with comments such as "he is used to cast iron; to steel; to brass or bronze, or perhaps to aluminium." So far as the technical and research leaders of the industry are concerned, it is difficult to agree that too much specialisation is conducive to achieving the best all-round results in practice. A fully-qualified foundry metallurgist should have a reasonable general knowledge of the origin and manufacture of all metals and a specialised knowledge of cast metals and their behaviour when poured into moulds of various kinds.

There are so many common factors in the construction of moulds that it has always been a source of wonder why there should be such opposition on the part of so many craftsmen moulders who have worked in one class of metal to engage in another class of metal. We have so often been compelled to suffer an inadequacy of skilled labour on the ferrous-metal side when, at the same time, the non-ferrous metal department has been short of orders for castings. A general knowledge of the gating and feeding of all cast metals should form part of the basis of apprentice training. The qualifications of a leader in the foundry should include this general knowledge. The design and volume of liquid-shrinkage feeder gates and heads for steel, malleable iron, aluminium bronze and light alloys are somewhat similar and their mutual study helpful. The treatment of these metals could well be studied by those engaged in cast iron, especially high-duty and alloy cast irons.

In the last resort, all our efforts are directed to producing more and more and better things for the well-being of all. In the United States the increase in the rate of productivity during the past decade, measured in output per man-hour, is equal to doubling the output in 26 years. In 1900 there was one engineer to 250 industrial employees, but to-day there is one to every 60. Chemists have doubled in 15 years and physicists in eight years. The number of scientists, technologists and engineers in industrial and Government research laboratories is four times as large in 1952 as it was in 1932. Science and technology are, therefore, the pathfinders to industrial efficiency and we are seeing still more clearly the economic shape of things to come, if the rate of consumption of raw materials does not outstrip the natural supplies which may be available in the world. Finally, industrial research and professional management have paid high dividends. Normally unprogressive firms have been compelled to interest themselves in research to keep up with their naturally research-minded competitors. A wise Government expenditure on scientific research is returned many times in the economic advantages which accrue to the State.

* Entitled "Science, Technology and Craftsmanship—As I See It," delivered at Blackpool, on Wednesday, June 17, 1953, during the 50th annual conference of the Institute. Abridged.

OXYGEN EQUIPMENT FOR THE EVEREST EXPEDITION.

IN modern times, records are established almost daily by machines; men are only the controllers. On the 1953 British Mt. Everest expedition, however, the order was reversed: the triumph was of men—men who followed the great traditions of mountaineering by relying as much as possible on their experience and ability as climbers. Nevertheless, the use of oxygen breathing equipment was evidently an important factor in the success which attended Colonel H. C. J. Hunt's expedition. The equipment was developed and supplied by Normalair, Limited, Yeovil, in conjunction with other firms and various Government departments, and we are indebted to them for the following account of development and design work.

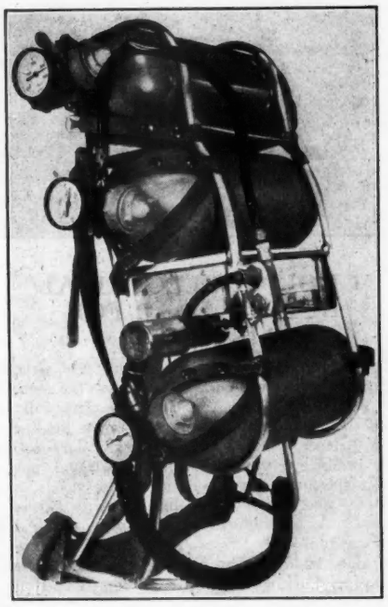
EARLY DEVELOPMENT.

Oxygen equipment was employed by earlier Everest Expeditions, but it was crude and generally unsatisfactory from the user's points of view, mainly due to the necessity of sacrificing efficiency for lightness in weight. As a result, some climbers tended to mistrust the equipment and regard it as causing more trouble than it was worth. However, in 1952 serious attempts were made to obtain reliable oxygen equipment which could be tried out during a training expedition on Mt. Cho Oyu, in readiness for a full-scale attempt on Mt. Everest in the following year. Early in 1952, at a meeting held to discuss the possible manufacture of six sets of oxygen equipment, it was agreed that as far as possible existing equipment should be used, since the design, manufacture, and testing of entirely new equipment would be virtually impossible in the short time available. The Royal Aircraft Establishment had already investigated the form the equipment should take, and subsequently all climbing sets were made in accordance with their recommendations. As soon as the information brought to light at the meeting was available, Normalair Limited, set to work to produce the equipment.

The existing equipment mentioned above consisted of a high-pressure cylinder; a pressure reducing regulator, giving a reasonably constant pressure; two orifices, either of which could be selected, depending on the flow of oxygen required, and a storage reservoir for the continuous flow of low-pressure oxygen thus made available. The principle of operation was similar to that of the Royal Air Force system used during the second World War. The complete set was carried in a fabric haversack to reduce the weight to a minimum. The high-pressure cylinder was of anodised light alloy. Weighting 5·5 lb. empty, it contained about 600 free litres of oxygen at 3,600 lb. per square inch. An adaptor was made to allow the pressure-reducing regulator to be fitted. The latter was manufactured by Siebe, Gorman and Company, Limited, Tolworth, Surbiton, and was similarly made of light alloy. Suitably modified, it was capable of giving reasonably constant reduced pressures for supplies of up to 3,600 lb. per square inch. David Harcourt, Limited, Birmingham, 10, supplied the pressure gauges, specially developed for such work.

The reduced pressure from the regulator was fed to the dual manifold assembly, which, by means of its two controlling orifices, could give the choice of two flows. Flow rates of 2 and 4 litres per minute for altitudes of 27,000 ft. were specified. The orifices of the dual outlet were produced by trial-and-error methods. Laboratory setting figures had to be corrected to allow for altitude and temperature variations, and a factor of approximately 1·17 was obtained; i.e., the orifices were set to 2·34 and 4·68 litres per minute with a reduced gauge pressure of 40 lb. per square inch. A flexible tube was fitted between the manifold assembly and the regulator. Tests showed that the braided tubing was capable of withstanding over 200 lb. per square inch and yet still remain flexible at a temperature of − 30 deg. C. Attachment of the rubber tube to the regulator was by means of a modified wing-nut which permitted an internal tube to butt on to the threaded outlet. A further soft-rubber flexible tube fitted on to the downstream side of the dual manifold assembly led to a rubberised fabric bag, the neck of which had another tube to carry the oxygen to the climber's mouth. No face mask was used.

A number of these sets were completed and used by the 1952 training expedition on Mt. Cho Oyu. Carrying trials were made at altitudes of 20,000 ft., and certain physiological data were obtained. Results could not be considered conclusive, however, since at 20,000 ft. oxygen is not essential, provided the climbers adopt their normal practice of acclimatisation. No further work in developing or constructing climbing equipment was done until after a meeting, held in August of that year, to discuss the supply of equipment for the 1953 British Everest Expedition. At this meeting, the experience of the Cho Oyu training expedition was discussed and it was agreed that in view of the short time available it would be unwise to depart appreciably from the existing design. However, it was decided to try to increase the capacity of the oxygen cylinders and to adopt the use of economisers and face masks. The previous method of using a tube clenched in the mouth, together with the added encumbrance of the loaded reservoir bag, was not ideal, in that the climber had to remember



to open and close his mouth at the correct moment. By using an economiser and face mask, the climber has only to begin to breathe in for a valve in the economiser to open, when all the oxygen stored during the exhalation period is delivered to the mask under slight pressure.

DEVELOPMENT OF PRESENT EQUIPMENT.

As an initial estimate it was suggested that 40 assault bottles would be required, together with the various fittings for 12 climbers. After two further meetings in the autumn of 1952, requirements were finalised and preparations put in hand. The Ministry of Supply offered to assist in the supply of standard R.A.F. equipment; the Reynolds Tube Company, Limited, Birmingham, 11, were to supply the light-alloy tubing; and Normalair, Limited, and Siebe, Gorman and Company, agreed to manufacture the equipment required.

In November, 1952, Normalair, Limited, took delivery of 60 Siebe, Gorman regulators, and modification and testing of them were commenced without delay. They were set to give a reduced pressure of 40 lb. per square inch for a flow of 5 litres per minute, with a supply of 1,800 lb. per square inch. Further tests were carried out after they were assembled to the bottles. Meanwhile, Normalair, Limited, had designed and built an economiser similar to the standard Service economiser. It proved most satisfactory and a further 12 economisers were commenced.

Originally, 40 assembled oxygen bottles and 12 dual manifold assemblies were requested, but the requirements were increased, and eventually Siebe, Gorman and Company were requested to supply some 40 standard R.A.F. bottles, fitted with modified brass regulators, and 60 standard R.A.F. valved cylinders which could be used in conjunction with a number of loose regulators for sleeping sets. The required number of dual manifold assemblies was increased to 35. Although it had been decided that oxygen should be used as much as possible by day and by night at all altitudes above 21,000 ft., flow rates were still not finalised. Consequently, Normalair, Limited, were requested to supply the dual manifold assemblies with flow rates in pairs of 2 and 4, 2·5 and 5, and 3 and 6 litres per minute. This was, perhaps, the best solution, since it is impractical to simulate mountain conditions at ground level and at the same time take into account the effects of acclimatisation.

Due to the fact that there were considerable differences of opinion as to the form the light-alloy oxygen bottles should take, no definite conclusions had been reached. Finally, to simplify portage, it was agreed that they should be of the conventional cylindrical shape. The general problem of carrying the equipment now had to be tackled. Mr. T. D. Bourdillon, a member of the Everest Expedition, suggested that the bottles and an economiser should be carried on a frame. At his request, Normalair, Limited, constructed a light frame to carry two bottles and an economiser; it weighed about 3 ounces. Ultimately, after several modifications and extensive tests, a final design was decided upon and 12 such frames produced. These were capable of carrying up to three bottles and, being more robust, were somewhat heavier.

Early in February, 1953, it was suggested that there was every possibility that the climbers might find a small number of high-pressure oxygen bottles which had been left by the Swiss Everest Expedition. For these bottles to be of any use the British climbers would need suitable adaptors. Consequently, a representative made a visit to the Swiss manufacturers, Draegerwerk, at Lubeck. It was established that the bottles would be most suitable for use in conjunction with sleeping sets, and the details of the adaptors required were obtained. Twelve such adaptors were manufactured, together with two pressure-gauge assemblies to indicate bottle pressure.

Meanwhile, deliveries of the oxygen bottles had commenced. Unfortunately, their weight was not as low as had been hoped, being about 8·25 lb. each; however, a number of bottles in the later consignments were lighter, being some 7·5 lb. each. But there were only ten of such light weight. The bottles had to be assembled and tested. This involved fitting each bottle with a Siebe, Gorman pressure regulator at one end and an end plug at the other. This did not, at first, prove an easy task; barely 50 per cent. success was obtained in obtaining pressure-tight joints. After a little experience, however, it was found that a 90 per cent. success could be obtained without too much difficulty.

After the bottles had been charged by the British Oxygen Company, Limited, they were returned for further testing. A number of bottles showed leakage at 3,300 lb. per square inch where previously no leakage had been apparent at 1,800 lb. per square inch. These had to be resealed. Finally, 57 of the bottles were made absolutely leak-proof, and the remaining three had a slight leak which did not exceed two litres per year. As it was thought that an oxygen bottle was likely to be jettisoned at the summit of Mount Everest, it was considered an excellent idea to apply a Union Jack transfer to each bottle. Because of the variation in weight of the bottles, it was further suggested that a useful means of identification would be to mark the lighter bottles with two Union Jacks.

The 12 carrier frames made by Normalair, Limited, were subsequently fitted with webbing manufactured by Gatehouse and Sons, Yeovil. The webbing was based on that used on the Commandos' haversacks, considerable effort being made to obtain the best possible method of securing the bottles to the frame. Subsequently, the 12 complete sets of climbing equipment were finally

assembled. Low-temperature tests were made for a period of over two hours, during which the change-over of bottles and variation of flows were carried out. Only minor difficulties were encountered. To assist the climbers in the use of the equipment, an instruction manual was prepared, copies being made available to the members of the Expedition before their sailing date, February 12.

DESCRIPTION OF PRESENT EQUIPMENT.

Each set of climbing equipment, as shown on page 779, provides a total of 2,400 litres of oxygen, compressed into three cylinders; the duration of each bottle depends on the flow selected. The weight of the complete pack with the bottles fully charged to 3,300 lb. per square inch is 40 lb. However, it was thought probable that in practice only two bottles would be carried, thereby reducing the weight to approximately 29 lb. The bottles, together with an economiser and a dual manifold assembly, are carried on the light tubular carrier frame. Each bottle is provided with a Siebe, Gorman pressure regulator which reduces the bottle pressure to approximately 40 lb. per square inch. The regulator is fitted with a pressure gauge to indicate the pressure available in the bottle and has an outlet which provides a connection for the flexible braided rubber tubing. The latter is protected by a number of short lengths of P.V.C. tubing, and delivers the oxygen at a reduced pressure to the dual manifold assembly.

The dual manifold assembly, as the name implies, has two outlets: one for use when a low flow of oxygen is required, and the other for use when a higher flow is required. Each outlet is marked, in litres per minute, to show the flow obtained when the connection is made. All the manifold assemblies were modified by Normalair, Limited, to give the desired rates of flow. At the same time, a neat relief valve was embodied to prevent excessive pressures damaging the flexible rubber tubing. The outlet of the dual manifold assembly is connected by a short length of rubber tubing to the economiser. A further length of flexible tubing is led from the economiser for connection to the mask.

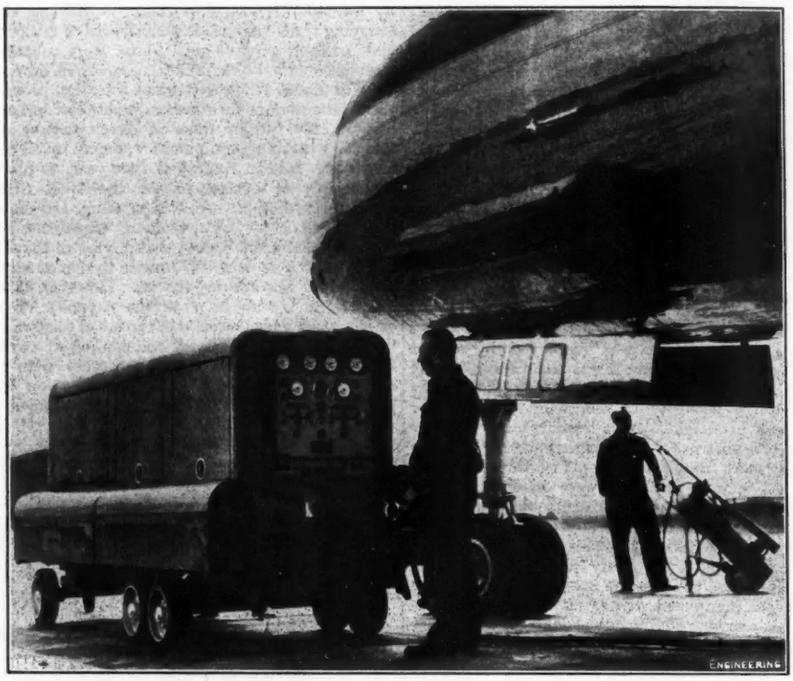
The carrier frame is shaped to fit comfortably on the climber's back and is carried ruck-sack fashion by means of two adjustable webbing straps. Two additional webbing straps are used to retain each bottle in the frame. These straps are secured by press fasteners so that the straps can be released quickly and easily when it is required to discard a bottle. The economiser and dual manifold assembly are rigidly attached to the frame.

To prepare the set for use the user merely has to connect the wing-nut end of the braided rubber tubing to the threaded union on the oxygen-bottle regulator. The bottles may, of course, be used in any order. The next step is to connect the short economiser pipe to the appropriate outlet of the dual manifold assembly by pressing home the bayonet fitting and turning it hard to the right.

The equipment is quite straightforward to operate; the user merely has to don his mask and turn the regulator valve to the "on" position. The high-pressure oxygen is then reduced to a nominal pressure, and passes through the rubber tubing to the dual manifold assembly. At this point it is metered—depending on the flow selected—and passes to the economiser. The final delivery of oxygen to the user is made from the economiser outlet to the mask. The set will then operate automatically. When the oxygen supply ceases or the pressure drops to 200 lb. per square inch, connection must be made to the second bottle. The empty bottle may then be discarded by pulling the loose end of one of its securing straps.

If any criticism can be levelled at this equipment it is probably at its weight. The apparently high weight is a result of making the equipment as efficient as possible, and it is doubtful whether a lighter set—using the continuous-flow system of operation—could be made without sacrificing efficiency. Should a lighter set be necessary, perhaps the best method is to adopt the use of the closed-circuit system. By this means the "unused" oxygen exhaled is not wasted and only the relatively small percentage of oxygen used needs to be made good. Mr. Bourdillon developed a set on these lines for use on the recent assault on Everest.

GROUND ELECTRICAL SUPPLY UNIT FOR AIRCRAFT.



GROUND ELECTRICAL SUPPLY UNIT FOR AIRCRAFT.

To supply electricity for the operation of aircraft electrical services while the aircraft is on the ground, and for starting the Avon engines that will be fitted in the Series 2 and 3 Comet air-liners, the British Overseas Airways Corporation have ordered a number of mobile ground power units, specially developed for their needs and suitable also for serving their present Series 1 Comets. A photograph of the unit, which has been produced by Messrs. Auto Diesels, Limited, Uxbridge, Middlesex, in collaboration with Messrs. Crompton Parkinson, Limited, Crompton House, Aldwych, London, W.C.2, is reproduced in the accompanying illustration. It provides for 112-volt and 28-volt direct-current supplies, the former for starting the Avon-powered Comets and the Bristol Britannias and the latter serving for the Series 1 machines and the general 24-volt services. The six-cylinder water-cooled Diesel engine driving the generating equipment, supplied by Messrs. Leyland Motors, Limited, Leyland, Lancashire, is one of their standard 11·1-litre industrial engines, developing a maximum power of 154 h.p. at 2,000 r.p.m., for which servicing facilities and spares are available throughout the world. The engine is capable of dealing with peak-load conditions at continuous rating.

The generating equipment, horizontally mounted on a common steel bedplate with the engine, consists of two Crompton Parkinson compound-wound generators, running at 2,000 r.p.m., directly coupled to the engine through flexible couplings, and each fitted with two end-shield heavy ball and roller bearings. One generator provides a 112-volt output at a continuous rating of 44·8 kW, 400 amperes and an overload rating of 95·1 kW, 850 amperes, for four 5-second peaks with 60-second intervals between the peaks. The other generator provides a 28-volt output at a continuous rating of 21 kW, 750 amperes, and an overload rating of 56 kW, 2,000 amperes, for six 10-second peaks with 60-second intervals between the peaks. The inherent voltage regulation under these overload conditions is $\pm$ 3 volts on the 112-volt system and $\pm$ 1 volt on the 28-volt system; automatic voltage regulators are not employed. Standard radio-interference suppression equipment, comprising condensers fitted across the brush gear, is also provided.

The unit is equipped with 96-volt and 24-volt batteries charged from the main generators. The 24-volt battery serves to provide a power source for the aircraft electrical services during refuelling, when the Diesel engine is shut down. The 96-volt battery is provided only for starting when the set is shut down. The switchgear for the two systems incorporates high-speed heavy-duty solenoid-operated contactors, operated by push-buttons, enabling any or all of the supplies to be selected, i.e. both 28-volt and 112-volt systems can be used separately, or simultaneously with loads up to 100 kW. Indicator lights on the instrument panel, and on the roof of the vehicle for observation by the aircraft crew, show which contactors are engaged. Protective relays, operated from the indicating instruments, trip the main contactors and safeguard the equipment against overload currents, generator over-voltage, and reverse current arising from feedback from the aircraft batteries. The reverse-current tripping mechanism operates at —2 per cent. of the full-load currents. The generator contactors will close only if the generator voltage is in excess of the associated battery voltage, and will not operate with reverse generator polarity. All the contactors are automatically tripped, without sparking, when the plug connection to the aircraft is broken.

The electrical instruments are of the Crompton Parkinson circular-scale type, resiliently mounted. They are grouped, together with the associated switchgear in two sections for the two systems, on the control panel at the rear of the vehicle, on which are also mounted the engine controls and instruments.

The equipment is mounted on a 5-ton six-wheel trailer, the bedplate forming the main chassis member, and is enclosed by a sheet-metal housing with retractable side and end panels. The roof is constructed to support two men, and has a non-slip surface. The equipment is provided with internal lighting, an obstruction warning light, a static earth in the form of a trailing non-ferrous chain, fire-fighting equipment, and cable stowage compartments. Modified versions of the supply unit are also made to suit specific requirements.

PRESSED FASTENING FOR SHEET METAL.

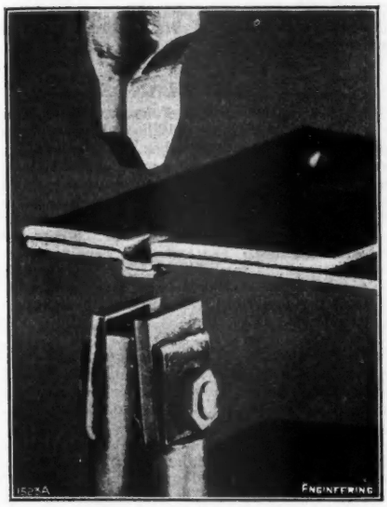


FIG. 1. SECTIONED STAINLESS STEEL JOINT.

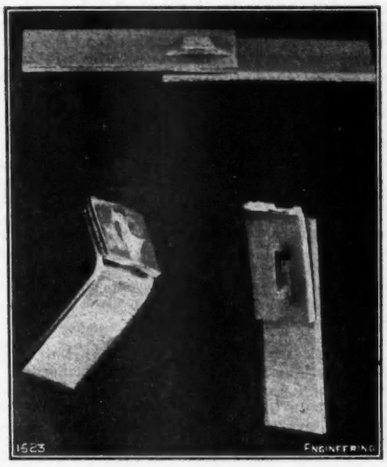


FIG. 2. TESTED JOINT IN ALUMINIUM.

JOINING SHEET METAL IN A PUNCH PRESS.

SPEED, simplicity and economy are the chief advantages of the method of joining two or more thicknesses of sheet metal which is shown in Fig. 1, above. A special punch and die, used in an ordinary punch press, act on the sheets in the following manner: the sheets are sheared in two parallel lines, the spacing and length of which depend on the thickness and type of sheet; the metal between the two shear lines is then rammed down, and, finally, it is compressed between the punch and the anvil of the die so as to cause it to spread slightly laterally, thereby effectively preventing the joint from working loose. The downwards movement of the metal is barely as much as the combined thicknesses of the two sheets; it stops just before two holes would be formed, one on each shear line. As the joint is rectangular in plan, it cannot pivot like a rivet or bolt, but in any case any number of such joints can be made according to the requirements of the particular job.

The Williams Metalacing technique, as it is called, was invented by Mr. Ivan A. Williams, of Portland, Oregon, U.S.A., where it was first used by several manufacturers so that it could be perfected. Subsequently the Crockatt Engineering Company, 1142-1143, Phelan Building, San Francisco 2, were made responsible for marketing the technique, and more recently, in this country, where patents are pending, W. Crockatt and Sons, Limited, 63, Darnley-street, Glasgow, S.1, have been appointed to make and sell the tools in sterling countries. The latter firm are also making, under license, a special machine which is intended for Metalacing work in cases where the quantities involved justify something more specifically suitable than a conventional press.

Metalacing is applicable to any sheet metal which can be sheared, drawn and upset. It can be used for joining sheet up to $\frac{1}{4}$ in. thick, the two sheets being of different metals if required. The punches and dies are made in a range of sizes to suit different thicknesses of sheet, etc., and the jaws of the dies are adjustable for the same purpose. A single joining operation is completed in a fraction of a second, and of course no additional material, such as is necessary with riveting, bolting, soldering, welding, etc., is required. The method is particularly advantageous in reducing the time for joining sheet metal, and has potential applications in pipe and duct work, the construction of road and rail vehicles, heating and ventilating equipment, sheet-metal shops generally, etc.

The sample joint shown sectioned in Fig. 1 has had brown paper placed between the two sheets to show up the nature of the joint. The sheets are of stainless steel, $\frac{1}{16}$ in. thick. Fig. 2 shows a joint in aluminium which proved under test to be stronger than the parent metal. Metalacing is said to compare favourably with rivets in strength.

MARINE TURBINE RESEARCH BY PAMETRADA.

(*Concluded from page* 728.)

THE 1952 annual report of the Parsons and Marine Engineering Turbine Research and Development Association refers to a wide range of researches on steam turbines, gas turbines, transmission, instruments and new techniques, the progress of some of which is summarised below.

STEAM TURBINES.

In connection with certain flow-meters required for full-scale testing of a further prototype set of naval machinery (Y.E.A.D. 1 trials), an electromagnetic device has been developed for determining the level of mercury in mercury-in-steel manometers. The prime purpose was to find an alternative detector to the radioactive source used in the A.R.D. unit. An accuracy of $\pm \frac{1}{32}$ in. is expected in use.

The Admiralty require a measurement of the dilation of the rotor bores at speed. It has been decided to measure the strain by an optical method. A cartridge containing mirrors is arranged at the point of measurement, and the change in bore is measured as the change in the mutual inclination of the mirrors, which form, essentially, a tri-hedral pyramid, by means of a modified Hilger and Watts auto-collimator.

An experimental unit has been designed to provide experience with high-temperature steam in conjunction with high pressure, and particular attention is to be paid to the performance of the special high-temperature materials used. The investigations will include the effect of thermal stressing and distortion of the austenitic-steel casing under changing temperature conditions. For this purpose, a rigid water-cooled framework has been designed and is arranged to fit round the turbine.

A turbine-blade research rig has been designed for investigating vibrations caused by steam excitation in impulse blading mounted either singly or in batches. The test-blade packs have been mounted in the test-turbine casing for the fundamental frequency of vibration to be measured. Apparatus has been designed for the optical layout and the arrangement of steam-proof magnetic vibration pick-ups. Orientating experiments are in progress.

An experimental condenser has been built for fairly fundamental investigation of such variables as tube layout, tube size, circulating-water velocity, fouling, etc. By the end of September, the rig was nearly complete and instrumentati is now well advanced. A single-stage air turbine has been designed to give information on the performance of various types of turbine blading when running under realistic turbine conditions, as compared with static cascade work.

Thermal distortion of a rotor resulting from a gland touch can be serious. A rig was therefore planned to provide data on the behaviour of different gland strip materials and configurations under rubbing contact. Design and manufacture of a suitable high-speed temperature-indicating unit are in progress. It is designed to scan 25 thermocouple E.M.F.'s every half-second. Photographic recording is used.

GAS TURBINES.

In connection with Admiralty work, a single-stage high-temperature liquid-cooled gas turbine has been designed and its manufacture begun. The light-alloy casing and entry duct are to have an internal refractory lining for external water cooling. At present the turbine is designed for ceramic nozzle blades, but development work is proceeding on sweat-cooled blading. The rotor blades are to be liquid cooled, in an independent circuit. The disc faces will be air cooled. Sealing of the circulating-water passages around the disc rim presented a severe design problem due to the large centrifugal forces, water pressure, and temperature stresses, but a welded design has been developed. Preparation of a rig for investigating heat transmission in rotor blades has proceeded during the year. It provides for a pair of dummy blades to be rotated at 11,000 r.p.m., 850 ft. per second, with heat supplied electrically.

A new combustion system has been evolved for use with the proposed high-temperature liquid-cooled gas turbine. It consists of four flame tubes, arranged in pairs facing one another, and exhausting into a common mixing space, the object being to obtain a uniform exhaust temperature distribution without having to match the sprayers accurately. It may even prove feasible in service to shut off one or more flame tubes at part load or in order to change a faulty sprayer. A special type of sprayer and fuel system has been designed for use with the multi-flame-tube combustion chamber, enabling one or more of the sprayers to be shut off at will from the control platform without affecting the others.

Details are given of tests on the 3,500-s.h.p. marine gas turbine. During the year the set was run for a total of 425 hours.

A number of cascades of turbine blades made by the Morgan Crucible Company, Limited, have been tested at Pametrada under realistic conditions of stress, temperature and thermal shock. Temperatures up to 2,200 deg. F. and stresses up to 2,000 lb. per square inch have been employed and some of the blades have withstood these conditions quite well, but others have failed almost immediately. Most of the trouble appears to occur during change of temperature, especially during the initial warming up, and it is clear that the method of mounting is very important. Calculations have shown that the stresses can be greatly reduced by the use of hollow blades. Meanwhile, work has continued at the Morgan Crucible Company on the development of improved materials and of methods whereby these materials can be made up into suitable shapes. Good progress has been achieved in both directions.

Other schemes of research work reviewed in the report relate to gas-turbine blade cooling by air, ash fouling and corrosion in gas turbines, back-to-back tests on gears, the measurement of temperatures in white-metal bearings, strain-gauging equipment, an electric field plotter capable of simulating flow phenomena in a two-dimensional plane, etc.

DIRECT-SWITCHING "PUSH-ON" STARTERS FOR ELECTRIC MOTORS.—The air-break direct-switching "push-on" starters which are now being made by Messrs. Allen West & Co., Ltd., Brighton, for controlling single-phase and three-phase squirrel-cage motors with outputs up to $\frac{1}{2}$ h.p. at 650 volts, have been designed for compactness. They incorporate a double-pole or triple-pole contactor, which connects the motor directly across the line, and mechanically-operated "start" and "stop-and-reset" push buttons. Over-current releases are provided as a protection against overload.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

ADDITIONAL FACILITIES AT PORT OF GLASGOW.—The question of additional berthage and other facilities, which may be required at the port of Glasgow during the next five years or so, has been under consideration by the Clyde Navigation Trust. It was reported at a meeting on June 9 that the subject had been discussed in a preliminary way at a joint meeting of the general purposes committee and the committees on new works, harbour, and traffic. Consideration of the project has been continued pending a report by the general manager and secretary, Mr. John Wilson.

INSPECTION OF ALBERT BRIDGE, GLASGOW.—A recent inspection of the Albert Bridge, spanning the river Clyde at Glasgow, has revealed "excessive vibration" in the north and centre spans on the west side of the bridge when it is used by fast traffic. Consequently, the Corporation have authorised Sir William Arrol and Co., Ltd., to carry out a full investigation of the bridge at a cost which is estimated to be about 600*l*.

DOON VALLEY DRAINAGE SCHEME.—Ayr County Council have been informed that the cost of the Doon Valley drainage scheme, including the laying of the main-valley sewer and the construction of purification works, originally estimated at 190,000*l*., is now to cost 285,690*l*. The site for the disposal works has been altered and an additional outfall sewer is to be constructed. These, together with increased labour and material charges, have caused the rise in the cost.

GLASGOW TROLLEY-'BUS SERVICE.—Glasgow's first trolley-'bus service through the centre of the city will be brought into operation on Sunday, July 5. The overhead equipment has been complete for some time, but the delivery of the vehicles has been awaited. By the opening date, 30 trolley-'buses will be available for the new service, from Clarkston to Firhill.

PROBABLE REMOVAL OF WRECK OF DESTROYER "MAILLÉ BRÉZÉ."—The wreck of the French destroyer Maillé Brézé, which sank in 1940 at the Tail of the Bank after an explosion on board, may be removed, it was stated at a meeting in Glasgow on June 3 of the Clyde Lighthouses Trustees. Lt.-Col. Hugh Campbell, deputy chairman, said that an underwater survey was being carried out by the Admiralty to decide whether it was practicable to remove the destroyer bodily. If this were practicable, he understood that the work would proceed at an early date.

GRAZING LAND FORMED BY BRACKEN CRUSHING.—Trial areas in Sutherland, Ross-shire, and Inverness-shire, which formerly approached "wilderness" conditions and were treated in 1951 and last year by systematic crushing with the Holt bracken-breaker, now provide "useful grazing land," according to reports from agricultural sources. It is added that, with the breaker on a hydraulic tractor mounting, 15 to 20 acres a day can be crushed at a low cost.

THE LATE MR. R. KELSO.—It is with regret that we record the death of Mr. Robert Kelso, which occurred on June 3, in the Isle of Arran, where he was born, at Brodick, on May 29, 1880. Mr. Kelso, who was until recently chairman of the General Steam Navigation Co., Ltd., entered the service of that company in London, in 1906. After long periods in various capacities at several Continental ports, he was elected a director in 1923 and became chairman and managing director in 1937, in succession to the late Mr. W. J. McAlister. Mr. Kelso had also been chairman of the Moss Hutchison Line, Ltd., the Great Yarmouth Shipping Co. Ltd., and the New Medway Steam Packet Co. Ltd., and had served as a member of Council of the Chamber of Shipping of the United Kingdom and of the Committee of Management of Lloyd's Register of Shipping. He was President of the Institute of Transport for the silver jubilee session of 1944-45.

CLEVELAND AND THE NORTHERN COUNTIES.

BUILDING OF WARSHIPS ON THE WEAR.—It is understood that the British Admiralty have ordered two fleet-auxiliary ships on the River Wear. Details of the ships, however, and the yards at which they will be built have not been announced. Two minesweepers are already building on the Wear. In the past it has generally been only in war-time that naval vessels have been ordered from Wear shipyards. During the late war, small vessels, such as tugs, frigates, corvettes, tank-landing craft and transport ferries were constructed on the river.

DISPOSAL OF COLLIERY WASTE AT SEA.—Waste from Lynemouth Colliery, Northumberland, is being removed by pipeline and dumped at sea. Stones, etc., are crushed before disposal. The plan is in the experimental stage and it is understood that it is not known yet whether the scheme is economical. It is stated that underground stowage would add another 5*s*. a ton to the price of coal.

NEW CONSETT COKE-OVEN BATTERY.—A new battery of coke-ovens, costing 600,000*l*., has been brought into use at the Consett Iron Works, Consett, Co. Durham. This is the first stage of a development plan which is to cost 2,000,000*l*. The battery is capable of carbonising 3,000 tons of coal a week, giving a weekly output of 2,200 tons of coke and 36,000,000 cub. ft. of gas. The coke will be used in the company's blast furnaces and the gas in the steel-melting furnaces. Future developments will provide for two, and perhaps three, new batteries of coke ovens.

IMPROVEMENTS AT TYNE DOCK.—At the annual meeting of the Tyne Improvement Commission at Newcastle, it was announced by Mr. B. E. Common, the chairman, that the new iron-ore handling plant and quay at Tyne Dock would not be completed until September. He stated that originally it was hoped to have the work finished by February this year, but there had been delays due to the steel position. The quay itself was almost ready, but the delivery of the cranes had been delayed. At the meeting, Mr. Common was re-elected chairman, and Mr. A. G. Everett, deputy chairman, of the Commission.

ACTIVITIES ON TEAM VALLEY TRADING ESTATE.—Work has commenced on the sinking of about 100 piles for proposed factory extensions, covering 30,000 sq. ft., on the Team Valley Trading Estate, Gateshead. The extensions are for Fusarc, Ltd., makers of welding equipment. Work is also to commence on factory additions for the Square Grip Reinforcement Co., Ltd., makers of steel reinforcement for concrete. A tender for the work has been accepted. Moreover, a contract will be let shortly for the construction of railway sidings in connection with proposed factory additions for Huwood Mining Machinery, Ltd.

TWO SHIPS TO BE BROKEN UP.—The 10,120-ton oil tanker Kuphus has arrived in the River Wear to be broken up by Thomas Young and Sons (Shipbreakers), Ltd. The vessel was built on the Tyne 40 years ago and was owned by the Shell Co. of Gibraltar, Ltd. Another vessel, the 8,000-ton steamer City of Canterbury, is to be broken up at Blyth, Northumberland, by the Hughes Bolckow Shipbreaking Co., Ltd.

LANCASHIRE AND SOUTH YORKSHIRE.

IMPROVEMENT IN SHEFFIELD LIGHT TRADES.—In the cutlery and small-tool industries of Sheffield the trade position is improving and, gradually, the number of workless and short-time operatives is being reduced. In hand tools and cutlery, Australia has given indications of resuming business with Sheffield on something like the old scale, later in the year. Lean times have been experienced for about twelve months.

LOWERING OF COAL STOCKS.—A diminution of coal stocks is regarded as inevitable in the South-Yorkshire and other coalfields, as a result of the extension of the miners' annual holidays with pay to a fortnight instead of a week as in previous years. Annual holidays are now well under way and will reduce coal production until the end of August. The exceptionally cold weather in early June has imposed a strain upon supplies of house coal at depots, and it has not been easy to meet the demand for house coal at the lower summer prices.

UNEMPLOYMENT STATISTICS.—During the month ended May 11, there were 1,142 men and 596 women without work in Sheffield. A further 421 men and 58 women were temporarily stopped. In the East and West Ridings there were 22,255 unemployed, representing 1·2 per cent. of the employed population, compared with 1·6 per cent. for the whole of Great Britain.

LONG-SERVICE AWARDS AT ELLAND.—On May 30, 25 long-service employees of Robert Dempster & Sons, Ltd., Rose Mount Ironworks, Elland, Yorkshire, all of whom had been employed by the firm for 40 years or more, were presented by the directors of the company with inscribed gold wristlet watches. Mr. B. C. Morton, managing director, who made the presentation, referred to the fact that the firm was rapidly approaching its centenary, which would take place in two years' time, and many of the present employees had served the firm for extremely long periods, the total length of service of those present amounting to 1,109 years. One of the recipients was Mr. W. Waterhouse, the foundry foreman, whose years of employment totalled 54. Mr. Morton himself also qualified for the award.

THE MIDLANDS.

BATHS AT A WILLENHALL FOUNDRY.—John Harper & Co., Ltd., ironfounders, Willenhall, Staffordshire, have opened an extension to their works baths. There are two sections, one for men, containing facilities for 80 men at a time, and one for women, containing ten shower cubicles. The latter, it is claimed, is the first of its kind to be erected at a foundry in this country. A number of women are employed in the core, paint and enamel shops. The company were pioneers in providing washing facilities for their employees, and the present extensions have been made as a result of repeated requests from the workpeople employed at the foundry.

OLD STEAM ROLLER.—We mentioned in these notes, on page 494, *ante*, an old steam roller which it was intended to preserve in the Museum of Science and Industry. The steam roller was built by the firm of Aveling and Porter in 1892 and has been very excellently restored at the works of Hunt Bros. (Oldbury) Ltd., Griffin Foundry, Oldbury. It travelled under its own steam from Oldbury to the Museum in Birmingham on June 7. The owners of the roller were Messrs. George Law, Contractors, Kidderminster and the original plates on its side show that it was the first to be registered under the Locomotives Act in Worcestershire, the eighth in Warwickshire and the eleventh in Staffordshire.

RISE IN CAR OUTPUT.—The Standard Motor Co. Ltd., Coventry, have achieved a 15 per cent. increase in production so far this year. The increase is based on three types of vehicle which have a considerable number of interchangeable parts. Orders are also in hand that will ensure an output, by the end of the year, of 175,000 Ferguson tractors, which are produced at the Standard Company's Coventry works.

SOUTH-WEST ENGLAND AND SOUTH WALES.

COAL EXPORTS TO PORTUGAL.—A drought in Portugal has stimulated the demand for South Wales coals. For some time past the electricity undertakings in Portugal, unable to operate their hydro-electric plants to full capacity, have been showing increasing interest in Welsh coals and have placed several orders. During the past week there have been inquiries for coal for the electricity and gas undertakings amounting to 15,000 tons.

BEAUTIFYING A COAL TIP.—The tradition of the black unsightly coal tips which have been a feature of the landscape in the South Wales mining valleys is not to be perpetuated at the new Nantgarw Colliery, the National Coal Board's "showpiece." It was announced at a meeting of the Glamorgan County Planning Committee that, as a result of a conference between representatives of the County Council, the Coal Board and other interested local authorities, plans had been drawn up for the suppression of dust at the new tip by the use of water spraying. Eventually, the tip will be covered with a layer of soil so that grass can be sown and maintained, and trees will be planted round the boundary of the tip.

STATISTICS OF UNEMPLOYMENT IN WALES.—Unemployment in Wales is higher than in the rest of the Kingdom, according to the latest returns issued by the Ministry of Labour. These show that the workless, in Wales, amount to 31 per 1,000 of the population. In the Welsh region, on May 11, however, there were 28,718 people idle, a decrease of 3,334 compared with the total at April 13.

PENGAM MOORS AIRPORT SITE FOR INDUSTRY.—The Cardiff Corporation Development Committee have decided to recommend the City Airport Committee to agree to the release of Pengam Moors Airport, the municipally-owned airfield, so that the site can be used for heavy industry. Alderman D. T. Williams, chairman of the committee, urged that the Board of Trade should be approached without delay.

NEW SOURCES OF WATER FOR CARDIFF.—Cardiff Waterworks Committee are to investigate all potential sources of water. They have agreed to examine the possibility of obtaining water from wells at Ely, Cardiff, and will ask analytical chemists for reports on the water in the rivers Taff, Ely and Rhymney. At present, the city's water engineer has estimated, there is a deficiency of 1,300,000 gallons a day.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section:* Thursday, June 25, 7.30 p.m., Star and Garter Royal Hotel, Victoria-street, Wolverhampton. "British Watch and Clock Production," by Mr. R. Lenoir.

ROYAL SANITARY INSTITUTE.—Thursday, July 2, 10.15 a.m., Town Hall, Walsall. (i) "Land Use in Walsall, with Special Reference to Slum Clearance and Reclamation of Derelict Land," by Mr. M. E. Habershon; and (ii) "Some Avenues to a Better Environment," by Mr. James Green.

LAUNCHES AND TRIAL TRIPS.

"CITY OF DURBAN."—Twin-screw liner, with accommodation for 106 passengers and cargo, built by Vickers-Armstrongs Ltd., Walker-on-Tyne, for Ellerman Lines, Ltd., London, E.C.3. Last vessel of a series of four for these owners. Main dimensions, 500 ft. between perpendiculars by 71 ft. by 41 ft. to upper deck; deadweight capacity, about 11,300 tons on a draught of 28 ft. 6 in.; gross tonnage, about 13,360; displacement, 19,640 tons. Two Hawthorn-Doxford six-cylinder opposed-piston heavy-oil engines, developing a total of 12,650 b.h.p. at 115 r.p.m., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Service speed, 16½ knots, fully loaded. Launch, May 28.

H.M.S. "EDDYREEF."—Single-screw vessel for carrying oil in bulk, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Naval Stores Department, Admiralty, London, S.W.1. One of a series of vessels for this service. Main dimensions: 286 ft. overall by 44 ft. by 18 ft. 6 in.; deadweight capacity, 2,095 tons on a draught of 17 ft. 2 in.; gross tonnage, 2,157. Triple-expansion steam engine, developing 1,750 i.h.p. at 227 r.p.m., constructed by Lobnitz & Co., Ltd., Renfrew; and two oil-burning cylindrical boilers constructed by the Caledon Co. Speed in service, 12 knots. Launch, May 28.

M.S. "LAURELWOOD."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for John I. Jacobs & Co., Ltd., London, E.C.3. Main dimensions: 512 ft. between perpendiculars by 72 ft. 6 in. by 41 ft. 2 in.; deadweight capacity, 18,200 tons on a summer draught of 30 ft. 6 in. N.E.M.-Doxford six-cylinder opposed-piston oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14½ knots. Launch, May 28.

M.S. "CHLOE."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Compania Armadora Transoceanica, S.A., Panama. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in.; deadweight capacity, about 24,600 tons on a draught of 32 ft. 3½ in. N.E.M.-Doxford six-cylinder two-stroke single-acting opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14 knots. Launch, May 28.

M.S. "BRUCELLA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for J. Marr & Son, Ltd., Hull. Main dimensions: 190 ft. 6 in. overall by 31 ft. 6 in. by 16 ft. 6 in.; fishroom capacity, 15,500 cub. ft. Eight-cylinder Diesel engine, developing 1,220 b.h.p. at 240 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, May 30.

S.S. "WORLD ENTERPRISE."—Single-screw oil tanker, built by Vickers-Armstrongs Ltd., Walker, Newcastle-upon-Tyne, for World Tankers Corporation, Monrovia. Main dimensions: 663 ft. overall by 86 ft. by 45 ft. 9 in.; deadweight capacity, about 32,500 tons on a draught of 34 ft. 5 in. Double-reduction geared turbines of Pametrada design, developing 12,500 s.h.p. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Steam provided by two Foster Wheeler oil-burning boilers. Speed, 16 knots. Trial trip, June 4.

M.S. "QUEENSBURY."—Single-screw cargo vessel, with accommodation for a small number of passengers, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Alexander Shipping Co., Ltd. (Managers: Houlder Brothers & Co., Ltd.), London, E.C.3. Seventh vessel built for these owners. Main dimensions: 430 ft. between perpendiculars by 59 ft. 9 in. by 39 ft. 3 in. to shelter deck; deadweight capacity, 10,650 tons on a draught of 26 ft. 8½ in. Two Gray-Polar six-cylinder Diesel engines, geared to one propeller shaft through hydraulic couplings and single-helical reduction gearing, and developing a maximum of 4,315 s.h.p. at 110 r.p.m., constructed by the Central Marine Engine Works of William Gray & Co., Ltd., West Hartlepool. Trial trip, June 5

CONTRACTS.

HOLLOWAY BROS. (LONDON) LTD., 157, Millbank, S.W.1, have obtained the first contract in connection with certain improvement works authorised by the Port of London Authority on the north side of the Main Dock, Tilbury Docks, to provide suitable accommodation for the larger vessels of the Peninsular and Oriental Steam Navigation Co. and the Orient Steam Navigation Co. The contract provides for the demolition and removal of the war-time "Pluto" installations; the demolition of No. 1 shed and part of No. 2 shed, and the existing quay wall at No. 1 shed, and the construction of a monolith quay wall 843 ft. in length with a return section of 240 ft., having a depth of water alongside of 42 ft. 6 in. below T.H.W.

THE FRASER AND CHALMERS ENGINEERING WORKS of the GENERAL ELECTRIC CO., LTD., Magnet House, Kingsway, London, W.C.2, are to provide a coal-preparation plant to be installed at Cwm Colliery, in the No. 3 (Rhondda) area, South Western Division of the National Coal Board. The plant will treat two different grades of coal and comprises two separate units, each capable of dealing with an input of 200 tons an hour. Each section is to be equipped with a Chance washer and froth flotation and water-clarification plant. The contract also includes a 25-ton "Marshall" wagon tippler and interconnecting raw-coal and refuse conveyors and bunkers.

THE YORKSHIRE HENNEBIQUE CONTRACTING CO. LTD., Viaduct Works, Kirkstall-road, Leeds, 4, are to supply post-stressed concrete beams for use at the Wakefield, Ardsley, Sunderland, Bowes Bridge, Goole, and Sowerby Bridge motive-power depots of the North Eastern Region of British Railways.

THE BRUSH ELECTRICAL ENGINEERING CO., LTD., have received an order for a 1,000-kW back-pressure turbo-alternator set from the South Johnstone Sugar Milling Association, Queensland, Australia. The set is a duplicate of that supplied to the same client and commissioned early this year. In the case of the new equipment, the exhaust steam from the turbine will be used for processing the sugar.

JOHN BLACKWOOD HODGE & CO. LTD., Hunsbury, Northampton, have secured a contract, valued at 600,000*l.*, for 40 Euclid tractors and scrapers and a fleet of Euclid rear-dump wagons to be used on the Yemathin district project of the Burmese Irrigation Department. Work on the scheme, which involves the construction of 19 dams, commences next year and will take three years to complete.

Contracts have been placed by the British Electricity Authority, during May, for power-station, transforming-station and transmission-line equipment, amounting, in the aggregate, to 6,120,467*l.* The principal orders include: for Hackney power station, circulating water intake works, with JOHN MORGAN (LONDON) LTD.; for East Yelland power station, near Barnstaple, two 30,000-kW condensing plants, with G. AND J. WEIR LTD.; for Goldington power station, Bedford, 3·3-kV 100-MVA oil-break and 415-volt switchgear and accessories, with A. REYROLLE & CO. LTD.; for Castle Donington power station, near Derby, 3,300-volt indoor air-break auxiliary switchgear, with the BRITISH THOMSON-HOUSTON CO. LTD.; for Northampton power station, two 150,000-lb. per hour stoker-fired boilers, with BENNIS COMBUSTION LTD.; for Hams Hall "C" power station, near Birmingham, the main civil engineering work, with SIR R. MCALPINE & SONS (MIDLANDS), LTD.; for Ferrybridge "B" power station, Yorkshire, one 100,000-kW turbo-generator, feed-heating and condensing plant, with C. A. PARSONS & CO. LTD., and access road and drainage, railway embankment and sidings, and other works, with CHAS. BRAND & SON, LTD.; for Keadby power station, Scunthorpe, main and auxiliary cables, with W. T. HENLEY'S TELEGRAPH WORKS CO., LTD.; for Wakefield power station, Yorkshire, reinforced-concrete frames, roofs, floors, etc., for the turbine-house and service block, with HOLST & CO. LTD.; for Huncoat power station, Accrington, three 305,000 lb. per hour boilers, with SIMON-CARVES LTD.; for Grove-road and Lodge-road substations, London, 66,000-volt, 11,000-volt and 6,600-volt and auxiliary cables, with BRITISH INSULATED CALLENDER'S CABLES LTD.; and 132-kV overhead transmission lines, from Eynsham to Yarnton, Oxfordshire, and from Marchwood to Nursling, Hampshire, with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., and from Castle Donington to Leicester, Castle Donington to Toton, and Daventry to Rugby, with RILEY AND NEATE, LTD.

DAVID BROWN & SONS (HUDDERSFIELD) LTD., have obtained an order from the Aluminium Company of Canada, Ltd., for the supply of 350 "Coventry" geared motors giving a choice of 17 output speeds ranging from 25 r.p.m. to 345 r.p.m., with input powers of from 0·25 h.p. to 2 h.p. The motors will be used to raise and lower the electrodes employed in the reducing furnaces at the large smelting plant which the Aluminium Company are building at Kitimat, 400 miles north of Vancouver.

PERSONAL.

Five appointments have been made to the Minister of Supply's Advisory Council on Scientific Research and Technical Development, namely, PROFESSOR H. W. MELVILLE, F.R.S., Mason Professor of Chemistry, University of Birmingham; PROFESSOR J. L. M. MORRISON, Professor of Mechanical Engineering, University of Bristol; PROFESSOR L. ROSENHEAD, F.R.S., Professor of Applied Mathematics, University of Liverpool; PROFESSOR I. N. SNEDDON, Professor of Mathematics, University College of North Staffordshire; and PROFESSOR A. R. TODD, F.R.S., Professor of Organic Chemistry, University of Cambridge.

MR. LESLIE GAMAGE has been re-elected President of the Institute of Export for the eleventh time in succession.

COLONEL R. B. EMERSON, C.I.E., O.B.E., M.Inst.T., has relinquished his directorship of Dowsett Holdings Ltd., Tallington, Stamford, Lincolnshire, on his appointment as chairman designate and chief executive of the proposed Nigerian Railway Corporation.

MR. T. W. SANDERSON has been appointed manager of Brigham & Cowan, Ltd., ship repairers, South Shields, in succession to MR. J. W. PHILLIPS, who retired recently.

MR. T. F. HARGREAVES, B.Sc.(Eng.), A.M.I.E.E., has joined the equipment division of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2, as a consultant on the overall planning of radio and telephone communication systems and to consider general applications of electronics.

MR. F. CURT SMITH, founder and chairman of the Visco Engineering Co., Ltd., Stafford-road, Croydon, has now retired after 32 years with the company. COLONEL G. MALLETT, M.C., T.D., has been elected chairman and MR. FRED. C. SMITH will continue as managing director.

The Minister of Transport has appointed MR. R. A. LOVELL, O.B.E., M.I.Mech.E., to succeed the late MR. A. E. N. TAYLOR, B.Sc.(Eng.), A.M.I.C.E., as deputy chief engineer, electrical and mechanical engineering branch.

Monsanto Chemicals Ltd. have announced that MR. J. M. KERSHAW has been transferred to the overseas division of the Monsanto Chemical Co., St. Louis, as their London development representative. He will be stationed in London and will be responsible to Dr. W. D. Scott, director of development of the division.

MR. W. SCOTT WARNER and MR. GERALD W. RICHARDS have been elected to the board of High Duty Alloys Ltd., Slough, Buckinghamshire.

Brown, O'Sullivan & Partners, consulting engineers, 123, Victoria-street, London, S.W.1, announce that DR. T. P. O'SULLIVAN, M.I.C.E., has relinquished his partnership and that the practice will be continued in the name of C. B. BROWN AND PARTNERS.

MR. J. F. SMITH, of Cardiff, has been elected President of the South Wales Branch of the Association of Mining Electrical and Mechanical Engineers for the ensuing year, in succession to MR. R. H. MORGAN.

MR. T. O. STEVENTON, of "Hawkstone," Vineyard-road, Wellington, Shropshire, has been elected a director of Turton Brothers & Matthews Ltd., Wentworth-street, Sheffield, 6. He will continue to represent the company in the Midland and South Wales districts.

MR. J. W. HISLOP has joined the sales staff of Lang Pneumatic Ltd., Wolverhampton, and will shortly operate in the London area in conjunction with MR. L. A. BOOBYER, the London sales manager.

MR. P. T. BLISS has been made sales director of G. A. Harvey & Co. (London) Ltd., Greenwich Metal Works, London, S.E.7.

ROLLS-ROYCE LTD., Derby, and the WESTINGHOUSE ELECTRIC CORPORATION, Philadelphia, have signed an agreement which provides for technical co-operation between the two companies for ten years. It is added that, subject at all times to the approval of the Governments of the United Kingdom and the United States, the agreement includes the exchange of information on the design, development and production of gas-turbine aircraft engines and a limited interchange of personnel.

MR. K. W. WEST, late of the Bristols Instrument Co. Ltd., has joined the staff of the Crosby Valve and Engineering Co. Ltd., Ealing-road, Wembley, Middlesex, as technical sales manager.

TECALEMIT LTD., Plymouth, Devon, have opened a new Scottish regional office at 86, Cambridge-street, Glasgow, C.2, managed by MR. E. R. HART; a northern regional office in North-road, Wetherby, Yorkshire, managed by MR. S. H. SMITH, and a London and Midland regional office in the Great West-road, Brentford, Middlesex, managed by MR. L. R. HEDGCOCK.

SIR W. G. ARMSTRONG WHITWORTH & CO. (IRONFOUNDERS) LTD., Gateshead-on-Tyne, announce that their name has been changed to ARMSTRONG WHITWORTH (METAL INDUSTRIES LTD).

EXHIBITS AT THE BRITISH PLASTICS EXHIBITION.

(*For Description, see Page* 788.)

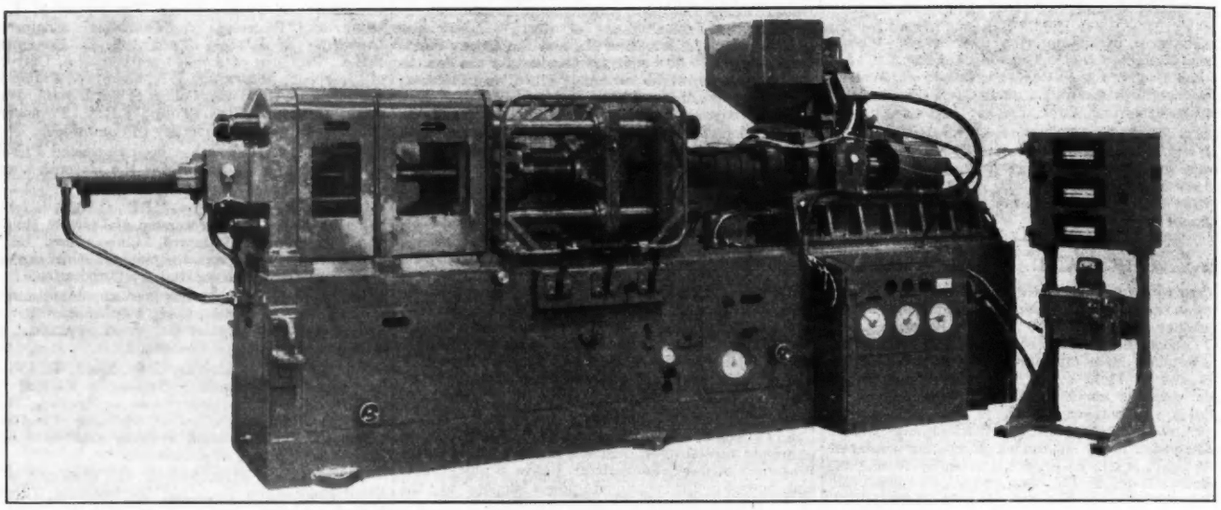


FIG. 4. PRE-PLASTICISING INJECTION-MOULDING MACHINE; R. H. WINDSOR, LTD.

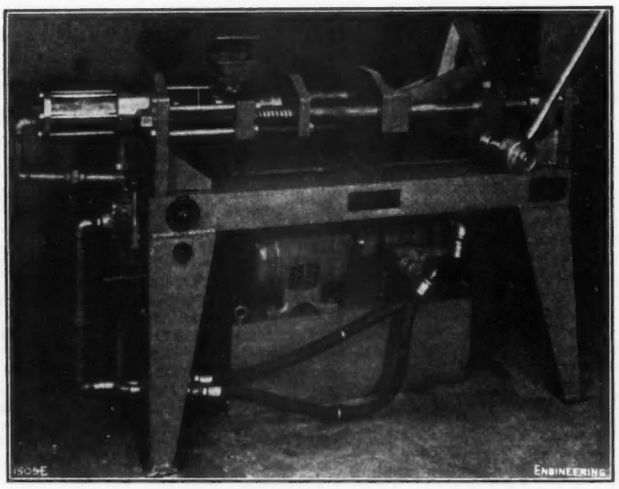


FIG. 5. 15-GRAMME INJECTION MOULDING MACHINE; DOWDING & DOLL, LTD.

FIG. 6. INFRA-RED PLANT FOR SOFTENING THERMOPLASTIC SHEET; GENERAL ELECTRIC CO., LTD.

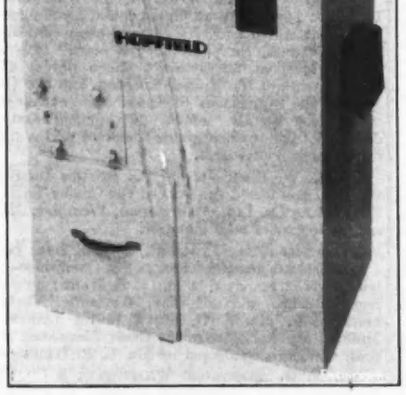


FIG. 7. PLASTICS-GRANULATING MACHINE: HUFFIELD BROS., LTD.

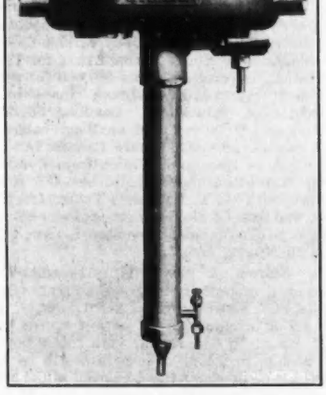


FIG. 8. AUTOMATIC ELECTRIC WATER STILL; MANESTY MACHINES, LTD.

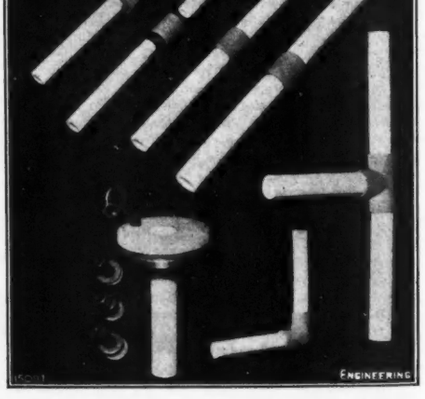


FIG. 9. "ALKATHENE" PIPE FOR COLD-WATER PLUMBING; I.C.I., LTD.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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SUBSCRIPTIONS.

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For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 174.

The Index to Vol. 174 of ENGINEERING (July-December, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

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THE NAVAL REVIEW.

SOME 15 square miles of ships, and only the largest out of hailing distance of their immediate neighbours, made the Queen's Coronation Review a spectacle which will be remembered vividly by all who saw it on Monday last, June 15. We were probably not alone in wondering, before the event, what sort of an impression would be created by a review containing only one solitary battleship —H.M.S. Vanguard; but let it be said at once that the display of naval power which awaited Her Majesty's inspection was as impressive, in the light of current circumstances, as any that has been held in the historic waters of Spithead. Indeed, to those who could look beneath the surface of such naval parades, it was definitely more impressive than its predecessor of 1937. The ponderous battleships have gone, their place being taken by the aircraft carriers; for the most part, the cruisers have gone, too—there were only a dozen of the type, under the British flag, out of more than 200 ships in the review, and of that dozen the Devonshire has long ceased to be a warship in anything but name; and even the destroyers were less numerous than they have been on former occasions. But it must be borne in mind that nowadays the design of warships can, and does, change materially within the lifetime of a single ship; and no one who saw the fleet in array at Spithead, as we were privileged to do, can entertain any doubt that the Royal Navy is fully abreast of modern developments and requirements so far as its ships and men are concerned. By divesting itself of certain types which, by long-established custom, had come to be regarded as the essentials of a serviceable fleet, it has placed itself in advance of other navies, and not behind them.

If battleships still count for anything—a debatable point—H.M.S. Vanguard is surely comparable with the best. If aircraft carriers are to be accepted as the real capital ships of the present and future—another debatable point—again the Royal Navy is as well equipped as any, and vastly better than most. In cruiser strength, admittedly, the Navy is not so strong as it might be; but, before condemning the Board of Admiralty (or, indeed, Parliament—the true arbiter) for this state of affairs, it is well to consider dispassionately what functions there are which the cruiser can still perform, that the destroyer or frigate of the present day cannot perform with equal efficiency and probably a much greater economy. In fire power, the modern destroyer is the equal of a cruiser of 20 years ago; in speed, her equal or superior in all but exceptional weather; and in general "usability" in any waters and all manner of circumstances, the destroyer can be at a disadvantage only in communities which regard bulk and the number of funnels as the measure of a warship's latent capabilities.

The Review consisted, so far as Her Majesty's ships were concerned, of one battleship (H.M.S. Vanguard), nine aircraft carriers, twelve cruisers, four vessels of the Daring class, which are intermediate between cruisers and destroyers, 26 destroyers, 44 frigates, 28 submarines, and a fleet of smaller craft too numerous and diverse to particularise. The truly heartening feature about them, however, was not their size, but the fact that they provided so many more opportunities than before for independent commands to be held by the young men from whom must be chosen the admirals of the future. How many of these ships, and of the officers who commanded them, have actually known the service conditions of war, we have not computed; but they had a very definite air of practical efficiency, in spite of the complex masses of top-hamper that modern science has forced upon the naval architect. That Her Majesty is well served by her Royal Corps of Naval Constructors, and by the builders of the Navy's ships, has seldom been better demonstrated.

Of the foreign warships present, the Russian cruiser Sverdlov probably attracted the most attention. As a ship, she is certainly noteworthy, and her appearance is much more attractive than was that of the battleship Marat, which represented the navy of the U.S.S.R. in 1937. In general outline, she is more than a little reminiscent of the later German practice in the design of heavy cruisers, though her array of optical rangefinders recalls also the former British battleship Royal Sovereign, which was lent to Russia during the second World War. The United States cruiser Baltimore and the French cruiser Montcalm also inspired favourable comment, though both are of types which are hardly likely to be repeated in either of their respective navies, so rapidly has the pattern of naval operations changed during the past decade. All the visiting warships presented a smart appearance, as, indeed, was to be expected, but it was left to the Italian navy to stimulate the imagination with a reminder of what Spithead looked like in days long past; for the square-rigged Italian training ship Amerigo Vespucci—like the Vanguard, conceivably the last of her type—had her yards manned. It is an intriguing reflection that this should have been seen in Spithead on the day which also saw the completion, by H.M. submarine Andrew, which has been on loan to the Royal Canadian Navy, of a voyage of some 2,500 miles, accomplished entirely under water.

NOTES.

THE "PRINCESS VICTORIA" INQUIRY.

THE MINISTRY OF TRANSPORT inquiry into the loss ,on January 31, of the Stranraer-Larne car-ferry the M.V. Princess Victoria, was opened in Belfast on March 23 and concluded on May 9. It was conducted by Mr. John H. Campbell, Q.C., who was assisted by Professor A. M. Robb, D.Sc., Mr. J. Shand and Captain C. V. Groves as assessors. The findings of the Court of Inquiry were published on Thursday, June 11, in the form of answers to 48 questions referred to the Court by the Ministry. The principal conclusions reached were that the vessel was unseaworthy in that the stern doors to the car deck were not sufficiently strong to withstand the impact of the heavy seas that might be reasonably expected to occur in the North Channel, and the arrangements to free the car deck of any water which might have been shipped were also inadequate. The blame for this deficiency was attributed to the owners (British Railways), who were also censured for having failed to take precautionary action after an incident in November, 1951, when the doors were burst open by a sea; and for having omitted to report that incident to the Ministry. as they were required to do under the terms of the Merchant Shipping Act of 1894. The Court commented adversely on the fact that, if the master had required advice or assistance from a higher authority, there was no one nearer than Euston, 400 miles away, to whom he could apply. They were of opinion that no blame attached to Messrs. William Denny and Brothers, of Dumbarton, who built the ship, or to Lloyd's Register of Shipping; but they were critical of the fact that there was no seagoing tug stationed at Belfast or any other of the Northern Ireland or adjacent Scottish ports. Particular commendation was recorded of the rescue efforts of Captain James Kelly, of the cargo vessel Pass of Drumochter; of James Nelson, coxswain of the Donaghadee lifeboat, and his crew; and of David Broadfoot, the wireless operator of the Princess Victoria, who "remained at his post to the last, transmitting accurate messages in circumstances of the utmost difficulty and danger," and was lost with the ship. The officials of British Railways have stated that they are withholding comment on the report until they have had the opportunity to study its full text; but subsequently it was announced that steps have been or are being taken to strengthen the car-deck doors of other ferries owned by British Railways.

THE ROYAL AERONAUTICAL SOCIETY'S GARDEN PARTY.

This year the annual garden party of the Royal Aeronautical Society was held on Sunday, June 14, at Astwick Manor, Hatfield Aerodrome. Since 1953 marks the first 50 years of powered flight, the flying display aimed at showing a representative selection of aircraft developed over the period, and the printed programme included "pages from an aviation scrapbook," from 1903 to 1953, which took the form of reproductions of aeronautical news cuttings of outstanding interest. Probably the most interesting of the flying events, which was not included in the official programme, was a brief visit of the Handley Page Victor prototype crescent-wing bomber aeroplane; although the aircraft has been seen previously over the suburbs and country north of London, this was probably the first view for many of the visitors attending the garden party. At the other end of the scale, it was most satisfying to see the 1912 Blackburn monoplane and the 1910 Deperdussin monoplane once again airborne under their own power; these two aircraft are part of the Shuttleworth collection of historical aircraft, and are powered, respectively, by an 80-h.p. Le Rhone engine and a three-cylinder 28-h.p. Anzani engine. Three Hawker machines of widely differing functions—the last Hurricane fighter to be constructed, a Hart light day-bomber biplane (used widely during the second World War for training pilots) and the Tomtit trainer biplane, opened the flying programme with an excellent display of formation flying. Representatives of the first World War included the Sopwith Pup single-seat scout aeroplane and the Bristol F2B fighter. Among other aircraft appearing in the display were the Canadian de Havilland Beam small transport aeroplane, widely used by Canadian "bush" operators, an Autogiro C.30, the Westland Sikorsky S.51 and Bell helicopter, an English Electric Canberra aeroplane, and the Avro 707 delta-wing research aircraft. There was also a static display of engines, ranging from the 80-h.p. Le Rhone engine of 1912 to a scale model of the Bristol coupled-Proteus power unit; this exhibition also included the prototype Gloster E 28/39 aeroplane (the first British jet-propelled machine) and a model glider and some of the radio equipment for controlling it, developed by the Low Speed Aerodynamic Research Association. The glider has now been equipped with a slow-burning solid fuel rocket developing 4-lb. thrust for 90 seconds.

THE POSITION OF RURAL ELECTRIFICATION.

Speaking at a conference of members and officials of the British Electricity Authority at Torquay on Monday, June 8, Lord Citrine said that, in view of the importance of rural electrification to the national well-being, it was probable that consultation with the Government on the subject would be necessary. There was little doubt that the demand for a widespread extension of electricity supply to rural areas would become more insistent and that more capital would be necessary for the development of this load. The problem was how the extension could be carried out without involving the Area Boards in serious financial losses. In 1948, the number of electrified farms was 80,849—about 27 per cent. of the total number. Since then some 46,000 additional farms had been connected, bringing the total up to 129,500 on March 31, 1953, or 43 per cent. of the whole. Electricity consumption by farms had increased by about 170 per cent., compared with the year immediately preceding April 1, 1948, and in 1952-53 had been 17 per cent. more than in the previous year. While there was no reason to be complacent, it was evident that steady progress was being made.

ACCIDENT INVESTIGATION ON B.O.A.C. "COMET" AIR-LINER.

The report has been published of the investigation ordered by the Government of India into the loss of the Comet air-liner G-ALYZ, operated by British Overseas Airways Corporation, which crashed shortly after taking off from Dum Dum airport, Calcutta, on May 2, with the loss of all on board, while on a scheduled return flight from Singapore to London. The principal findings of the Court are that the aircraft encountered a north-westerly squall and thunderstorm soon after taking-off, when climbing to its cruising altitude, and suffered structural failure in the air which caused a fire. It is believed that the structure was overstressed, either as a result of severe gusts encountered in the thunderstorm, or as a result of the pilot applying too severe control loads, or losing control, when flying through the thunderstorm. The Court recommend that a further detailed examination of the wreckage should be undertaken to consider whether any modification to the Comet structure is necessary; and that consideration should be given to the desirability of modifying the control system of the aircraft to give the pilot a positive "feel" of the airloads on the control system. A possible primary cause of failure, which the Court consider requires greater investigation, has been suggested by one of the assessors: in both elevators the spars showed evidence of a bending failure under down load, and there was also evidence of a fuselage failure in bending under a down load on the tail. The assessor deduces that the aircraft may have adopted a nose-down attitude in a down-gust, and that the pilot may have applied the elevators to pull the nose up. A sudden elevator failure would have imposed a heavy down load on the wings, resulting in a wing failure. Both extension wings were found to have failed at about the same point, where the wing structure changes from two heavy spars to an outboard shell construction. Damage to the fuselage and tail surfaces is believed to have been caused by contact with the broken wings, which, smeared with kerosine, are also considered to have caught fire and communicated it to the rear end of the aircraft as they passed through the jet blast.

TELEVISION AT THE CORONATION NAVAL REVIEW.

Successful arrangements were made by the British Broadcasting Corporation to "televise" salient events in the Naval Review at Spithead on June 15. Cameras of the Image-Orthicon type, made by Marconi's Wireless Telegraph Company, Limited, Chelmsford, and Messrs. Pye, Limited, Cambridge, were used for this purpose, two of them being installed on shore in Portsmouth Dockyard and at Fort Gilkicker, near Stokes Bay, respectively, and others afloat on H.M.S. Eagle and H.M.S. Reclaim. In the case of the ship-borne equipment, the cameras were in duplicate and on H.M.S. Eagle the aerial was attached to a gyro-controlled mounting so that it maintained a constant azimuth bearing regardless of the ship's position. Both vision and sound signals were transmitted from each of these points over specially installed radio links to a mobile central control room, which was set up at the Admiralty Signal and Radar Establishment at Portsdown, near Portsmouth. A further link was used to transmit a mains locking signal to the ship-borne cameras so as to maintain them in synchronism with the apparatus on shore. From Portsdown, the programme was transmitted to a receiving station near Alexandra Palace through two relay stations, radio links operating on a wave length of 3 cm. having been provided by the Corporation for this purpose. The equipment for these radio links was supplied in part by the two firms mentioned above, as well as by Standard Telephones and Cables, Limited, the General Electric Company, Limited, and Mullard, Limited, London. From Alexandra Palace the programme was fed to all the British Broadcasting Corporation's television transmitting stations. Sound broadcast commentaries were also transmitted from a number of the ships by radio link to a main reception point at Southsea Castle and thence, together with those from various shore commentary points, to London and other transmitters. Provision was also made for the European and Overseas services to be supplied either directly or by means of records.

JUBILEE OF BIRMINGHAM ALUMINIUM CASTING (1903) CO., LTD.

The Birmingham Aluminium Casting (1903) Company, Limited, Smethwick, 40, celebrated the 50th anniversary of their founding on May 5. To mark the occasion, the company entertained to dinner at the Grand Hotel, Birmingham, a large number of guests, who were welcomed by Lord Burghley, K.C.M.G. (chairman of the company), and Mr. E. Player and Mr. J. W. Berry (joint managing directors). The company was actually founded in May, 1903, but it developed out of an earlier undertaking, the Hydraulic Joint Syndicate, which was a product of the bicycle boom of the 'nineties. The hydraulic joint—a method of producing cycle frames without brazing—was not a success, and the Syndicate encountered difficulties. At this juncture, one of the members, Mr. Walter H. Maudslay, took over the managing directorship. He was the grandson of Henry Maudslay, of screw-cutting lathe and slide-rest fame, and was the last managing director of the famous marine-engineering firm of Maudslay, Sons and Field. It was clear to Mr. Maudslay that the hydraulic joint could never be successful, and he sought other means of reviving the fortunes of the Syndicate. Among the suggestions considered was an idea for making the joint by casting aluminium round the tubes. It was tried, and proved successful. Brazing, as is well known, eventually became the standard method of joining the tubes in cycle frames, but the use of aluminium had a profound effect on the fortunes of the Syndicate. The metal aluminium

was, at that time, relatively obscure, but it was not long before it became the Syndicate's principal concern. Very soon, the first order for aluminium castings for the motor-car industry was received, from the then newly-established Clement-Talbot Motor Car Company, Limited. By 1901 it had become obvious that the future of the business lay in aluminium castings and it was reconstituted as the Birmingham Aluminium Casting Company, Limited. There was a further change of title, in 1903, to the Birmingham Aluminium Casting (1903) Company, Limited, since when the story has been one of steady progress. Mr. Cyril C. Maudslay, son of W. H. Maudslay, who had joined the Board in 1907, became assistant managing director in 1911, and, with Mr. Frank Gower, who had been appointed manager in 1904, took up the Cothias method of die-casting. Thus the foundations were laid for another activity which is now an important branch of the Birmal business. In the days immediately preceding the 1914-18 war, Birmal pioneered the die-cast aluminium piston, though it went unrecognised in this country at first. In 1920, Birmal moved to the present site at Smethwick, then owned by the Midland Motor Cylinder Company. Mr. Cyril Maudslay joined the board of the Midland Motor Cylinder Company, and from that company there came to Birmal a year or two later a young man whose name was to become well known throughout the entire group of which Birmal is now a part. This was Mr. Percy Pritchard, who became joint managing director of Birmal in 1927, and immediately set about investigating the possibilities of pressure die-casting. He was also responsible for the acquisition of the Coventry firm of Sterling Metals, Ltd., in 1929. In 1929 he took out a patent for the corrosion-resisting alloy "Birmabright." In 1936 a new company, Birmid Industries, Limited, was founded, to act as a holding company, and Birmal became one of its subsidiaries. Mr. Pritchard died in 1945, and was succeeded by Mr. Edward Player, managing director of Sterling Metals, Limited. Mr. C. C. Maudslay was chairman until 1951, when, owing to advancing years, he retired in favour of Lord Burghley, who is also chairman of Birmid Industries, Limited. Mr. J. W. Berry became joint managing director with Mr. Player in 1948. To-day, the Birmal foundries manufacture sand, gravity and pressure die-castings in aluminium, magnesium, and zinc alloys.

ACTIVITIES OF THE BRITISH RUBBER DEVELOPMENT BOARD.

The annual reports for 1952 of the British Rubber Development Board, and of its research unit, Rubber Technical Developments, Limited, have just been published, and at the fifteenth annual general meeting of the Board, held on June 8, 1953, Mr. Egmont Hake, C.B.E., the chairman, said "there was heartening evidence that in the guerilla campaign of Communist terrorism in Malaya, the initiative had passed to the forces of law and order." The reports show that much work has been done on examining means of expanding world consumption of rubber, and the largest and most promising field appears to be in connection with roads; during 1952, 32 stretches of rubberised road were laid and the full-scale surface dressing of rubber and bitumen laid on the Great South-West Road forms the basis of other road-surfacing trials to be completed during this year. Campaigns to promote a more general use of latex foam, of rubber in agriculture and industry, and on railways, were started; the result of these campaigns was that the Board had to deal with over 100,000 inquiries for information on rubber and distributed nearly 500,000 copies of 42 newly-produced publications on the subject. The report of Rubber Developments, Limited, shows how a pilot plant was set up in 1951 for the production of cyclised rubber, which is a powder requiring special separation equipment of the centrifugal or filtering type, and suitable dryers. This material is found to be an acceptable alternative to the synthetic high styrene/butadiene co-polymers. A pilot plant has been set up in co-operation with the Rubber Research Institute of Malaya.

LETTERS TO THE EDITOR.

TAKORADI HARBOUR EXTENSIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the report, in your issue of April 24, of the extension work carried out at Takoradi Harbour, Gold Coast. On page 532 you state that "The first jetties at Takoradi were built during the period 1895 to 1900." I think this statement is misleading, as the place where Takoradi Harbour was built was pure jungle, with the exception of two very small mud-hut villages, called Takoradi and Amanful. The first jetty at Sekondi was erected about 1895 and it appears that the reference concerned refers to the town of Sekondi.

In August, 1921, Messrs. Stewart and McDonnell commenced preparatory work on the new harbour. This included the construction of a European camp, Fort Orange, at Sekondi, and the construction of a road and railway from the last-mentioned place to Takoradi. The work also involved the construction of the railway line from the quarry to the site of the new harbour and, at a later date, the construction of a European camp, workshops and other ancillary works on the site of the new harbour. In 1924 it was decided to carry on the construction of the harbour on a contract basis, and Sir Robert McAlpine and Sons were the contractors who completed the work. Incidentally, I spent three and a half years on the construction of the harbour referred to.

Yours faithfully,
DUDLEY FARRANT.

103, Howards-lane,
London, S.W.15.
June 10, 1953.

COMPENSATION FOR PERSONAL INJURIES.

TO THE EDITOR OF ENGINEERING.

SIR,—In ENGINEERING of May 22, on page 660, *ante*, you published an interesting article by Mr. C. F. Mayson on the above subject. He has pointed out that the assessment of damages in these days nearly always falls to the lot of one of Her Majesty's judges: to invoke the assistance of a jury appears to be a practice which has gone out of fashion.

One reason for this may be that the judges of to-day appear to be far more generous than they used to be and, being aware of this, the plaintiff's advisers press for trial by judge alone. A judge takes into consideration, no doubt, the fall in the value of money; and, where diminution of earning capacity has resulted, has regard to the vast increase in wages which has come about in recent years. Possibly, a judge will also bear in mind that an employer is normally covered by insurance. While the decision of a judge on this question of damages is not final, it may be reviewed by the Court of Appeal—albeit with reluctance, and only in very special circumstances.

It is important to remember, however, that the Court of Appeal is still more reluctant to interfere with the verdict of a jury. In these circumstances the employer (and his legal advisers) might well consider whether it would not be better to press for trial by judge and jury instead of by judge alone. The quantum of damages would then fall to be decided by the jury under the direction of the judge. It may be, of course, that the juror of to-day would be inclined to give rather more to a successful plaintiff than the man who was sworn "to try the issue between the parties" 20 years ago; but it is not improbable that he would take a rather more conservative view than a judge, who, all unconsciously, would be inclined to follow the example of one of his learned brethren who had awarded enormous damages in a somewhat similar case.

Yours faithfully,
W. VALENTINE BALL.

18, Holland-street,
London, W.8.
June 6, 1953.

AN EXHIBITION OF MAPS.

AN exhibition illustrating the map-maker's art, and the tools he has used through the centuries, is now open to the public, until July 4, at the Royal Institution of Chartered Surveyors, 12, Great George-street, London, S.W.1. There are 999 exhibits, and the 118-page catalogue is a valuable source of information on the subject.

The exhibition is probably unique, in that it is unlikely that so many ancient maps, and so many manuscripts and books relating to cartography, have before been collected together under one roof. The exhibits cover the period from the Sixteenth Century to the present day, with sequences showing the methods adopted to produce maps from aerial surveys and from the most exact trigonometrical triangulation. Exhibits constituting a series of surveys of the Great Park have come from the library of Windsor Castle, by permission of Her Majesty the Queen, who is Patron of the Institution. Almost two-thirds of the exhibits, however, come from the remarkable private collection of Mr. Cyril Kenney, a Fellow of the Institution.

The earliest exhibited example of a map is one by Gregor Reisch, dated 1504, which shows the world of Ptolemy, knowing nothing of the Americas and only hinting at the interior of the African continent. There are also several examples of the art of Christopher Saxton, the great cartographer of the First Elizabethan Era. Among the rare books is one dated 1599, by Edward Wright, professor of mathematics at Caius College, Cambridge, and colleague of John Napier, the inventor of logarithms. This book greatly influenced navigation, dealing, as it did, with "Certaine Errors of Navigation," which it attempted to right. Of interest to the mechanical engineer is Varlo's *Reflections upon Friction*, published in 1722, and Ladd's *A Succinct Description of the New-Invented Patent Chain and Wheel*, which first appeared in 1759.

In the sections devoted to antique and modern instruments, the earliest is a 6-in. quadrant in brass, which bears the inscription "Nova inventio et usus quadratis et bussolae adinventae ab adamo heroldo Germano cum privelegio S^{mi} dni nri Papae Gregory XV Anno MDCXXII." Among the modern instruments are the 5-in. and 3½-in. theodolites used for the 1936-52 primary and secondary triangulation of England, Scotland and Wales.

A section of the exhibition is devoted to certain maps of the last war, one of these being the map of Europe used in the British War Cabinet room, complete with its coloured pins showing the lines of the various armies as they swept into Germany in 1945. Another map, captured from the Germans, shows the progress of the Battle of Britain on August 14, 15 and 16, 1940, the losses incurred and the penetration effected. Other maps show the plans of the German High Command for the invasion of England in three waves, over the length of coast lying between St. Leonards-on-Sea and Folkestone.

Bringing technique right up to date are examples of surveys by aerial photography and contouring by aerial stereoscopy, while a whole section is devoted to the work of producing the maps of the Ordnance Survey Department of the Ministry of Agriculture and Fisheries. For this technique paper is no longer used; the initial drawings are made on square anodised-aluminium sheets of 20-cm. side, cut to within 0·01 cm. Then follows the photographing of four sheets, giving a glass negative of 40-cm. side, and the printing on sensitised metal sheet, which is then finished as the final map will appear. This is then photographed for the preparation of blocks for the final printing on paper.

NEW BROADCASTING STATION AT BEXHILL.—A new permanent transmitting station, which is expected to be in operation before the end of this year, is to be constructed by the British Broadcasting Corporation at Pages Lane, one mile west of Bexhill. It will have an output of 2 kW and will take over the 206-metre service which is at present being given by a temporary station, near Hastings.

OBITUARY.

PROFESSOR D. HANSON.

It is with regret that we note the sudden death of Professor Daniel Hanson, D.Sc. (Liv.), M.Sc. (Birm.), which occurred at his home, at Haselor, near Alcester, Warwickshire, on June 12. Professor Hanson, who had occupied the chair of metallurgy at the University of Birmingham for 27 years and was the Director of the Department of Metallurgy of the University, was the eldest son of the late Mr. Daniel Hanson, of Preston Brook, Cheshire, and was born in 1892. He received his general education at Wallasey Grammar School, subsequently going up to the University of Liverpool. Soon after graduating in science, he joined the staff of the Research Department, Royal Arsenal, Woolwich, in 1913, but, in the following year, was transferred to the scientific staff of the Department of Metallurgy in the National Physical Laboratory, Teddington, Middlesex. In 1922, Hanson received the degree of D.Sc. from the University of Liverpool, and later was promoted principal scientific officer at Teddington. It was in 1926 that Dr. Hanson was appointed to succeed the late Professor Thomas Turner in the Feeney Chair of Metallurgy in the University of Birmingham.

During his 12 years at the National Physical Laboratory, Dr. Hanson conducted a number of original researches, in collaboration with Dr. J. L. Haughton and the late Dr. G. D. Bengough and Dr. W. Rosenhain, on copper and copper alloys and, with Mr. S. L. Archbutt and Dr. M. L. V. Gayler, on the constitution and structure of aluminium and its alloys. Of late years Professor Hanson and his colleagues and research students carried out numerous investigations on the constitution and mechanical and physical properties of alloys of tin. Professor Hanson was elected to membership of the Iron and Steel Institute and the Institute of Metals in 1917, and served as member of Council of the latter body from 1925 to 1928 and from 1940 to 1944, and as a vice-president from 1928 to 1939. He delivered the ninth Autumn Lecture of the Institute, on "The Use of Non-Ferrous Metals in the Aeronautical Industry," at Southampton, on September 9, 1930. He was elected a Fellow of the Institution of Metallurgists in 1948.

BRITISH PLASTICS EXHIBITION AT OLYMPIA.

(*Concluded from page* 747.)

Pre-Plasticising Injection Moulding Machine.

At this exhibition, which closed yesterday, R. H. Windsor, Limited, Leatherhead-road, Chessington, Surrey, were exhibiting a new pre-plasticising machine, known as the S.H.8/10, which we illustrate in Fig. 4, page 784. It is claimed that this is the first time that a single-stage and an in-line system of pre-plasticising has been available, previous machines of this type having functioned in two stages. Among the advantages claimed for this machine is the fact that it shows complete cleanliness due to there being no bleed-back, and by pre-plasticising the raw material on the same machine articles of an increased size can be produced at a reduced cost. Its plasticising capacity is 140 lb. per hour and it will produce articles weighing up to 32 oz. of cellulose acetate which is equal to 44 cub. in. of fully plasticised material. At maximum capacity the injection can be completed in less than two seconds. The complete cycle of the machine, when using polystyrene and working at the maximum capacity, occupies slightly under one minute. It can exert a maximum pressure of 10,000 lb. per square inch, and the actual test figures obtained have been 4,000 lb. per square inch for polystyrene, and 4,300 lb. per square inch for cellulose acetate.

The complete cycle of operation of this machine commences at the material cylinder which contains a plunger that incorporates two specially-designed screws, and is housed in a barrel surrounded by electric resistance heaters. The two screws are of the Archimedian type and are used for feeding the material forward while it is being heated and plasticised. A hydraulic motor transmits power through a gearbox to the screws, and a hydraulic cylinder, and piston forces the injection unit forward. Once injection is complete, the material is again fed into the rear of the screws and delivered to the front of the barrel under pressure; this pressure gradually drives back the screws, the gear drive and the hydraulic piston against a predetermined pressure in the cylinder. The return movement can be arrested at any point of the stroke, and as it is relative to the weight of the shot required it can be set to serve the same purpose as the weigh-in method. The complete moulding operation ends with a cooling period. For the actual injection, the machine is closed and the plasticised material shot into the mould under pressure from the hydraulic cylinder; during this part of the operation, the screws are stationary and are pushed forward as the material enters the mould.

15-Gramme Injection-Moulding Machine.

On the stand of Messrs. Dowding and Doll, Limited, Greycoat-street, Westminster, London, S.W.1, the Westminster power-operated injection-moulding machine, which has a capacity of 15 grammes, was shown. The machine, which is illustraded in Fig. 5, on page 784, has been designed to meet the demand for a half-ounce moulding machine and is a modified version of the hand-operated Westminster machine. It is equipped with a self-contained power unit comprising a Vickers 1,000-lb. per square inch hydraulic pump and a 3-h.p. motor using a three-phase 400/440-volt 50-cycle supply. This machine, it is claimed, will give trouble-free production of 15-gramme mouldings having a maximum volume of 0·6 cub. in. For laboratory purposes the machine will produce mouldings weighing 1 oz. Its maximum mould casting area is 6 sq. in. The maximum daylight between the platens is 5¼ in. and the minimum daylight is 1½ in. The mould opens 6 in. A heating range of up to 250 deg. C. is possible, and the consumption of the heater is 350 to 500 watts. The total injection pressure of the machine is 8,750 lb., and the production rate at maximum capacity is 60 shots per hour. The distance between tie bars is 6½ in. and the working area of the platens is 6⅜ in. diameter, giving an area of 31 sq. in. The machine occupies a floor space of 51 in. by 22 in. and the approximate net weight is 7 cwt. As normally furnished it is complete with a band-type electrical heating element for 230 volts single-phase current but elements for other voltages are also available. A thermometer hopper, spanners and rack are included in the accessories supplied with the machine.

Infra-Red Heating Equipment.

The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, showed the 12-kW infra-red lamp plant, designed for the softening of thermoplastic sheet, which is illustrated in Fig. 6, page 780. It consists of a tubular floor stand supporting a horizontal bank of Osram infra-red reflector lamps. These lamps, which are mounted in reflector units, radiate downwards on to a flat bed the position of which can be adjusted relative to the lamps. The heating space is surrounded by doors with inner reflecting surfaces which open to permit the insertion of material from any side. When the doors are shut, the heating space is completely enclosed, thereby preventing any heat loss due to stray radiation and the cooling effect of air currents. The reflectors themselves are made of an aluminium alloy which gives a highly reflecting surface. When the apparatus is required for use in corrosive atmospheres or tropical conditions, the reflectors are usually replaced by others of which the reflecting surfaces are rhodium plated. The infra-red reflector lamps are rated at 250 watts 115 volts and are for operation on 200-250-volt supplies, and pairs of lamps are wired in series. This heating plant can also be wired for connection to a three-phase supply. It is suitable for heating areas up to 4 ft. by 3 ft. The height of the equipment is 4 ft. 6 in., width 4 ft. and length 3 ft. 6 in. A smaller model is also made of 5-kW capacity and this will heat surfaces up to 2 ft. by 2 ft. 6 in. The semi-transparent quality of most plastics assists in the uniform absorption of the heat and radiated; examples are cellulose acetate, "Perspex," acrylic sheet, etc. Softening is usually carried out prior to processes such as shaping by blowing or pressing. These heating plants can also be fitted with an automatic control which limits the time of heating or the final temperature attained by the material.

Plastics-Granulating Machine.

The granulating machine shown in Fig. 7, page 784, has been designed for use in the moulding shop. It enables all waste material from sprues, runners, and scrapped parts to be immediately processed into granules of a suitable size for re-use. The makers of this machine are Hupfield Brothers, Limited, Stanmore, Middlesex. It will handle materials including cellulose acetate, polystyrene, polythene, polyvinyl chloride, nylon, etc., at rates up to 80 lb. per hour for hard materials and somewhat lower rates for softer plastics. The machine which is of all-steel construction has the top of the cabinet formed as a tray which can be lifted off to give access to the motor drive and electrical equipment. The material for granulating can be sorted in the tray and then passed into a chute in the left-hand corner of the tray not visible in the illustration.

A three-bladed rotating cutter acting against a stationary blade slices up the pieces and when they are sufficiently small they pass through a sieve plate beneath the cutter. The holes in the plate are $\frac{3}{8}$ in. in diameter and give an average chip size of $\frac{1}{4}$ in. If other sizes of chip are required the sieve plate can be changed for another. The cutting blades are tipped with high-speed cutting steel and can be removed when necessary for regrinding. The material passes through the sieve and falls into the drawer which can be seen in the illustration. The main spindle and cutting head is made from high-tensile steel and the bearings in the spindle housing are provided with an effective seal against the dust from the ground material. The spindle is driven from a 2-h.p. motor using a 400-440-volt three-phase 50-cycle current, by two half-inch wide V-belts. The driven pulley is heavily made to act as a flywheel. The motor starter switch is mounted inside the cabinet behind the fuse-box for the incoming supply. This switch is connected to a simple push-button switch at the front of the machine and two safety switches are fitted to cut off the supply to the motor if either the front inspection plate, shown above the drawer, and held by four large screws, is removed, or if the cover tray is lifted from the machine.

Electric Automatic Water Still.

Manesty Machines, Limited, Speke, Liverpool, 19, showed the 00B electrically-heated water still illustrated in Fig. 8, page 784. The boiling chamber of the still is made of cast iron, the condenser pipe of steel, and the lid and baffle cup of heat-resisting glass, with an inner baffle of stainless steel. The condenser tube is made of either stainless steel or Monel metal, and is designed with a swaged-down nozzle at the end. The weir chamber has been designed with a removable plug to assist in cleaning. The height of the still is 29½ in. and it has a gross weight of 140 lb. Its output is 6 to 8 pints per hour, and its consumption is 3 kW. The heat is supplied by an electric immersion heater.

The operation of the machine is as follows: the inlet water enters at the lower end of the condenser, circulates around the stainless condenser tube and fills the boiling chamber to a height which is controlled by the weir. The condensing steam preheats the incoming water almost to boiling point before it enters the boiling chamber. The still is designed so that dissolved gases are expelled to the atmosphere. The baffling on the still causes the vapour to change direction three times before passing into the condensing tube. This system of baffling is said to prevent the entrainment of raw water and to make the still particularly suitable for use in districts where the water is hard, or with natural waters which have a tendency to froth.

Alkathene.

The theme of the Imperial Chemical Industries, of Millbank, London, S.W.1 (Plastics Division), stand was Plastics in Industry. One of the plastics shown was Alkathene, which has been used exten-

sively for cold-water piping. It can be screwed and machined and it is shown fitted to a standard type of pipe fitting in Fig. 9, page 784; Fig. 10, opposite, shows another application. Its properties make it suitable for carrying a variety of fluids and it is also an electrical insulator which is an advantage when the piping is used near electrical equipment. Alkathene is resistant to very strong acids and alkalis and the tube is unaffected by soils normally considered to be exceptionally corrosive. Similarly, corrosive waters, or those which dissolve lead, are not affected by the tube. Its elasticity enables it to respond to the expanding effect of freezing water and to recover completely when the ice melts. It is also a heat insulator. Its flexibility simplifies its handling and is an advantage when the tubes are used for mole drains. The nature of this material is said to reduce water hammer and sound transmission. A low density of 0·92 permits the manual handling of 500-ft. coils. The bore surface is smooth and the hydraulic friction is slightly less than that of metal tube. Its one disadvantage is that it softens with heat and is therefore unsuitable for hot-water distribution; it can, however, be used for low-pressure waste pipes where the hot discharge is at a reduced pressure. Two new British Standard Specifications, 1972 and 1973, were recently issued dealing with this pipe.

Also being displayed on the stand by the I.C.I. Nobel Division were nine silicones and examples of products in which these have been employed. There are three which possess low-temperature viscosity characteristics due to the inclusion of silicones, making them suitable for use in dashpots and other similar equipment. One of the three silicone resins shown is known as R.250 and is said to be a good impregnating resin; it is suitable for applications where reasonable flexibility is required. Its dielectric strength is 1,500 to 2,000 volts per mil; the power factor is 0·0026 and the dielectric constant 2·91. After three days at 100 per cent. relative humidity the resistivity at 25 deg. C. is $1{\cdot}8 \times 10^{11}$ ohms.

Resin Products

British Resin Products, Limited, 21, St. James's-square, London, S.W.1, together with their sister company British Geon, Limited, Barry, Glamorgan, exhibited a large range of their synthetic resins and plastic-moulding materials together with examples of applications selected from many industrial fields. The products can be divided into four main groups, namely, adhesives, industrial resins, moulding resins and surface-coating resins. Of the adhesives, several sub-divisions can be recognised according to their basic constituents and the purposes to which they can be applied. The urea-formaldehyde resins have been developed particularly for all forms of wood-gluing, such as the production of plywood and wood board as well as for veneering. There are two kinds of phenolic adhesives, those that are gap filling and contain a hardener so that they will set at room temperatures and those that have no hardener, but require a pressing temperature above 100 deg. C. The latter type have a high durability and a good life under adverse outdoor conditions of weather. Similar to the phenols are the resorcinol-formaldehyde adhesives which, as well as for wood, can be used for gluing both plastics and metals; they have the added property of setting under alkaline conditions. For bonding metal to metal, or metal to wood and other materials, the company have recently introduced "Cellobond" metal adhesive: a single component adhesive that requires both heat and pressure before the joint is made, although the workpiece may be taken from the press before it has cooled.

The industrial resins differ markedly in their characteristics according to the application but, in general, are intended to be used with reinforcing fillers, having particularly proved themselves when associated with those fillers that have been derived from glass. Other examples of their use include rubber compounding in the preparation of products ranging from soft vulcanisates to hard ebonites, as well as sand-core binders which enable a much-improved casting to be made. Of the moulding materials available, many have special properties such as high shock-resistance, or are proof against the attacks of acids or other corroding chemicals or have other particular physical properties such as a high insulating value. Exhibits that attracted considerable attention in this group were the polystyrene battery boxes as supplied for the Comet jet air-liners, and the transparent cases ordered by the Royal Mint as containers for the

FIG. 10. LAYING "ALKATHENE" DRAINPIPE.

Coronation coins. For use in the production of paints, lacquers, varnishes, stoving enamels and other surface coatings, the display included the "Epok" range of phenolic and maleic resins that have a high self-colour and varnish stability and which have but little tendency to yellowing as they age. Also displayed were the materials employed in the production of the modern emulsion paints, cold-setting lacquers and insulating varnishes.

CONFERENCE OF NOBEL PRIZEMEN.—The third conference of those who have been awarded the Nobel Prize for physics will be held at Lindau (Lake Constance) from Monday, June 29, to Friday, July 3. The object of this gathering is to interest the laity in recent advances in physics and to do this a number of lectures on a wide variety of subjects have been arranged. These include one by Professor Max Lane (who was awarded the prize as long ago as 1914) on "Interference by Röntgen Rays"; by Professor F. Soddy, on "The Natural Transformation of Radioactive Elements"; and by Professor P. A. M. Dirae, on "Quantum Mechanics and the Ether."

ELECTRICITY SUPPLY IN SCOTLAND.—The Moriston project of the North of Scotland Hydro-Electric Board has been amended in order to economise in the use of scarce materials without affecting the annual output, which is estimated to be about 213 million kilowatt-hours. Under the original scheme, it was proposed to develop the power in the lower River Moriston in two stages, but water will now be taken direct from a reservoir at Dundreggan to an underground generating station nearby and discharged thence into a tunnel leading to Invermoriston, where there will be a second station. A subsidiary station will also be built near the Dundreggan dam.

THE BRITISH ELECTRICAL POWER CONVENTION.

(*Continued from page 759.*)

THE discussion on Colonel Leeson's paper, an abridged version of which was given in last week's issue of ENGINEERING, took place on Tuesday afternoon, June 9.

DISCUSSION.

Mr. J. Eccles thought that it could not be said that a community which spent 16 per cent. of its total outgoings on alcohol and tobacco was incapable of spending more than the 1·5 per cent. which at present it spent on domestic electricity. On the industrial side the cost of electricity in various typical industries was only 1 per cent. of the value of their gross outputs. If doubling the quantity of electricity used in industry were to increase the output by only 25 per cent., the cost of electric power would still be a very small proportion of the extra output obtained. Whether doubling the amount of electricity used in industry would enable production to be stepped up by 25 per cent. would depend on its proper use. Three things were needed. First, those in control must demonstrate that they were working hard and effectively. Secondly, wherever possible production should flow from one end of the factory to the other as a group responsibility. Thirdly, people must have the right to spend a greater proportion of their earnings in whatever way they chose, instead of having them halved by taxation and quartered by purchase tax. Electricity was already making a national contribution to prosperity. While for many important commodities the increase in price had been from 300 to 600 per cent. since 1938, and in none less than 100 per cent., the average price of electricity per kilowatt-hour in his own area had increased by only 23 per cent.

Mr. H. W. Bosworth urged the necessity for greater production per head, by harder work, longer hours, or both, and for fewer non-producers both inside and outside industry. All industries, and the nationalised industries not the least, should eliminate the form-fillers and the time-wasters. The Government especially should be urged to abandon those expensive, time-wasting monopoly inquiries, for which all had to pay. There should be greater concentration on the types of work for which we were best fitted—scientific work, research and the production of high-quality goods. It was no use trying to compete in mass-produced goods with cheap labour abroad. There must be an abolition of all restrictive practices, an end to the penal taxation of undistributed profits, and some review of the demands of military service. There should be a ruthless use of this country's purchasing power to secure the entry of its goods into foreign markets. The reply to the recent action of the American authorities in connection with certain electrical tenders should have been to close the British market to American films and tobacco. Unless the Americans genuinely intended to expand their trade with us, we must learn to do without America and concentrate on trade with other countries.

Mr. W. A. Coates thought there would be general agreement that the greater availability of electricity in the past would have increased the chances in the export field to-day, and would still do so; but to some extent the position had changed since the end of the war. The electrification of the main line railways was an attractive idea, but how was the money to be obtained? The cost would be of the order of installing another 500 to 600 MW of generating plant, and the Treasury would never consent to that. Customers abroad were asking exporters to finance their purchases—the sort of thing which we ought to be doing for ourselves but could not afford to do. Exhortation was not enough to increase productivity. Leadership was wanted. Most people in managerial positions worked longer hours than their subordinates, and when they did so they should make the fact obvious. They should also undertake self-examination and make sure, for instance, that they were not calling for unnecessary reports. By a little study, senior

executives should be able to cut the amount of paper work in their organisations by from 10 to 30 per cent.

Mr. D. Maxwell Buist pointed out that before the war the ratio of home to export trade in the electrical industry had been about 85 to 15, and was now perhaps 60 to 40. He hoped that that proportion would be maintained to avoid having a very poor basic home industry. If, however, home demand were to increase *pro rata* with exports, there must be a removal of restrictions on capital investment, the lowering or abolition of purchase tax and a removal of the restrictions on hire purchase. Colonel Leeson's figures showed that while the total tonnage of goods produced had doubled since before the war, the tonnage of overseas exports had been multiplied by four times at least.

Mr. H. Midgley did not agree that exhortation was useless as a means of increasing productivity, and pointed out that half the trouble in the industrial world to-day was due to exhortation, but exhortation from the wrong people. More thought should be given to the problem of counteracting this. Mr. W. H. Dunkley emphasised the need for the stimulation and reward of inventiveness. There seemed too great a tendency in this country to live by importing other people's brains, and it was difficult to obtain any substantial reward for ingenuity in the service of a big organisation.

Mr. J. R. Harding suggested that in view of the fact that many overseas customers could only pay for capital equipment when it began to earn money for them, a body such as the Convention could with advantage tell the Government that a wider measure of support than that afforded by the Export Credits Department would be of great value. On the question of purchase tax, he thought that the Government should be urged to reduce the rate of tax as much as possible and then leave it unchanged for a period of years.

Mr. G. F. Moore said that it would be impossible to have a large programme of capital investment while maintaining the supply of consumer goods unless people were prepared to work longer hours; shift work would not be a solution. It would also be necessary to reduce the number of non-producers.

Electricity and Industrial Production.

The first paper presented at the meeting of the Convention on Wednesday morning, June 10, was by Mr. E. R. Wilkinson, on "Electricity and Industrial Production." Before the war, said the author, our imports had beensome thing like 800*l.* million and our exports 500*l.* million, the balance being met from the interest on our overseas investments and by income from shipping and financial services. Our overseas investments had now been replaced by debts exceeding 6,000*l.* million, so that, in the years which lay ahead, we should need an apparent trade surplus on our total annual balance of international payments of about 400*l.* million at to-day's price levels. The problem of achieving this objective had to be viewed in the light of existing world conditions. It was a world rent by idealogical conflict, the seller's market was over and competition would grow more intense. Moreover, most countries had come to realise the essential contribution which electricity could make to their efficiency and economy, with the result that their scale of development since the beginning of the war had been at least equal to the whole of the development which preceded it. Part of this expansion was attributable to changing living conditions and to the need for labour saving, both in the home and in the factory. Part, however, was due to the change-over from less efficient forms of power, as the availability, dependability and relative cost of electricity had improved, to the increased production per worker made possible by the flexibility and adaptability of electricity and to the increased range and complexity of industrial products, which meant that more work was required per article produced. There was, in fact, no doubt that the world was embarking on a phase of unprecedented expansion in the use of electricity for industrial production.

Certain special factors had to be taken into account in considering Great Britain's need for industrial electrification. A higher proportion of the "gainfully occupied" population were engaged in industry than in a group of eight European and American countries; the average age of the population was increasing; normal hours of work were shorter, and educational periods and holidays were longer. Moreover, we lacked agricultural self-sufficiency and the programmes of social reform had preceded rather than followed increased productivity. If these handicaps were to be overcome and economic viability achieved, the relationship which existed between productivity and the use of energy must be recognised. Moreover, there were some grounds for suggesting that the rate of increase in productivity accelerated as mechanisation became more comprehensive, in spite of the fact that it might be expected that in this case, as in others, the law of diminishing returns would apply. The explanation no doubt was that mechanisation was accompanied by more scientific management, better factory layout, a more highly-organised flow of materials and other improvements.

Statistics indicated that while in 1935 the United States consumed 2¾ times as much electricity per worker as we did in this country, the figure was now three times; and there were no signs of any improvement in the relative situation in the near future. In all probability, however, the shortage in industrial motive power was not our most important deficiency. We were apt to think of industrial electrical requirements in terms of the motor, but a distinguishing feature of post-war development had been the introduction of electronic and other devices, which were transforming the modern factory. As a result of their use, complicated functions could be performed without continuous supervision, and it was significant that, while some 20 per cent. of the American expenditure on fixed plant and equipment was at present devoted to electronic devices, the British figure in 1951 was only between 3 and 4 per cent.

All this led to the conclusion that more rapid industrial electrification was essential to rehabilitation. The difficulties in achieving such acceleration were, however, formidable, among them being acute capital shortage at a time when an efficiently equipped industry was essential to national preparedness in defence. The situation would not be so serious if similar difficulties were being encountered elsewhere, but an examination showed that, while in the seven countries which formed the greater part of Western Europe industrial capital investment between 1947 and 1950 had represented some 23 per cent. of their national income, in this country the average was only some 14 per cent. over the same period. This situation was only resolvable by securing the maximum re-equipment of industry with the minimum practicable capital expenditure. A major step in this direction would be a more general adoption of shift-working, as this would not only ease the competition for capital, but improve the load factor of many industrial consumers.

If, however, the industrialist was to be relieved of the necessity of spending capital on power plant and yet was to embark on large-scale machine re-equipment, he must be assured of the adequacy of the public power supply. So far there appeared to be insufficient appreciation of the paramount need for the highest priority being given to the construction of new power stations, as one of the main methods of increasing the national earning power. As a result, while in the seven Continental countries mentioned above capital expenditure on electricity supply between 1947 and 1950 represented an average of 9 per cent. of the total fixed capital expenditure by all industries, in Great Britain the average was only 7 per cent. In short, Western Europe had been devoting a larger proportion of its annual income to industrial capital purposes and had been allocating a greater share of that larger proportion to electricity supply.

Electricity Supplies for Industry.

Mr. Wilkinson's paper was followed by one on "Electricity Supplies for Industry" by Mr. A. O. Johnson and Mr. C. P. Holder. The authors began by analysing the consumption of electricity in the main industrial groups, both in 1935 and in 1948, to show the close relationship between those figures and those for productivity. It appeared that during the period under review the consumption of electricity had increased by 84 per cent., and in some of the major industries had nearly doubled. The increase in the amount of privately generated electricity was, however, only 15·6 per cent., so that there had been a marked rise in the proportionate use of public supplies. In both cases the cost of generation had been affected by the increase in the price of fuel, equipment and other items. Industry in Great Britain was made up of a large number of firms of various sizes, whose electrical requirements represented a wide range of individual demands and load characteristics. A survey carried out by the North-Western Electricity Board showed that consumers with loads between 40 kW and 200 kW constituted nearly 70 per cent. of the total, but that over 40 per cent. of the consumption was due to concerns with loads between 1,000 kW and 5,000 kW, who only represented 5 per cent. of the total. Again, 79 per cent. of the consumers had load factors below 25 per cent., but consumed only 42 per cent. of the total output. In designing standard industrial tariffs, the Area Boards had therefore to ensure that, while accurately reflecting the costs, they maintained equity between individual consumers. During the past 18 years, there had been a relative increase in fixed costs compared with running costs. A two-part tariff provided the most satisfactory basis for ensuring that the charges for electricity supplied to an industrial consumer reflected the cost of the supply, and with this structure it was appropriate for the maximum demand charge to allow for increases in fixed costs and for the unit charge to take account of the improvement in thermal efficiency.

Without including any consideration of the economies of electricity generation by back-pressure or pass-out sets (as this was dealt with in detail in another paper), the factors affecting the relative economics of private and public supply for lighting, motive power and such process heating as was carried out electrically were detailed, it being pointed out that the cost of producing electricity for any combination of these purposes was governed, not by the nature of the usage, but by the resulting overall load characteristics. It appeared that private plant was unlikely to be competitive with public supply, except when combined electricity and steam supplies were required; when very low-grade fuels or waste-heat were available; where large loads of low-load factor were being carried on old private plant; and where large loads of high load factor were being carried on new private plant. In practice, however, there were few cases where private plant was operated without some form of supplementary and/or stand-by supply from the public system.

Private plant might either be operated in parallel with the public supply or switches installed to enable a change over from one to the other system to be made. From the point of view of the supply authority, the greatest drawback of private plant was that it was not under their control; what was most feared was the failure of the human element, such as faulty synchronising, incorrect operation of switchgear or slowness in emergencies. The consequences of bad synchronising could be overcome to a large extent by an efficient system of protection. Equipment must also be provided to prevent the private plant feeding into a system fault or the system feeding into a generator fault. The private plant must be connected so as to ensure its own safety and the safety of those who operated it. It must also be operated so as not to cause interference with the supply to other consumers. The change-over switch method of operation, in conjunction with public supply, was relatively simple and cheap. In the event of a failure of the public supply it avoided the risk of the private plant tripping on overload. It was therefore particularly appropriate where the output of the private plant was small in relation to the total factory load.

Combined Electricity and Heat Supplies.

The next paper read at this meeting was on "Combined Electricity and Heat Supplies," and was presented by Mr. H. S. Prosser and Mr. A. W. Pedder, who sought to discover the fuel savings that were likely to be effected in the various fields of application of heat-electric generation and what would be the financial results. Dealing first with

domestic supplies, the authors estimated that each household at present consumed some 3 tons of coal per annum, which at an average utilisation efficiency of 26 per cent. meant a benefit of only 180 therms, costing about 1*s.* 7*d.* per therm. The heat consumption per dwelling with central heating schemes was, however, 600 therms per annum. The comparative merits of supplying such a scheme from back-pressure sets or by bled steam from a main power station or by direct production, were discussed in detail and the conclusion was reached that district heating would only economise in coal consumption if a main power station was available as a source of heat. The annual cost to the consumer would be from 50 to 100 per cent. more than with conventional methods of heating, depending on the size of the scheme and the method of providing the supply. The consumer would, however, receive some three times more useful heat. If the consumption per dwelling could be reduced to one half by metering or lowering the standard of heat, the cost per consumer would only be decreased by about 17 per cent., owing to the high first cost. District heating supplied by direct heat production would, compared with conventional methods, increase the coal consumption by 50 per cent. and cost at least as much as, and generally more than, heat-electric generation.

On the other hand, the district heating of commercial premises from a special heat-electric station would result in a substantial reduction in the coal consumed, compared with individual heating; although the cost per therm would only be less when a highly concentrated load was coupled with favourable distribution conditions. District heating by direct heat production would effect no appreciable saving in coal consumption, although it would be cheaper than a supply from a heat-electric station and more expensive than a supply from a near-by main power station. In considering industrial supplies the authors dealt with the production of process steam and compared the fuel consumption and cost of direct steam production with the cost of heat-electric generation. As a result of a detailed analysis they reached the conclusion that the results were much effected both by the total size of the installation and the load factor of the steam requirements. Moreover, the lower the pressure at which the process steam was used the more favourable the case for back-pressure generation, owing to the larger amount of electricity generated per pound of steam. Generally speaking, with a 25,000-lb. per hour installation the case for back-pressure generation was marginal at 80 per cent. steam load factor and was definitely not profitable if the load factor was as low as 40 per cent. With larger installations it was, however, worth-while at 40 per cent. load factor and highly profitable at 80 per cent. load factor. The overall coal savings at medium pressures varied from 10,000 to 17,000 tons per annum per 100,000 lb. of steam demand at 80 per cent. load factor.

Finally, various aspects of the idea of using a centralised heat power station to supply a number of factories was considered and the conclusion was reached that, while such a scheme had no great financial merits, in many cases it offered definite possibilities of reducing coal consumption.

Industrial Electrical Applications.

The final paper presented at the meeting on Wednesday morning was by Mr. T. B. Rolls, on "Industrial Applications of Electricity." The author gave descriptions of some of the more recent applications of electricity and its control and distribution. There was no reason, he said, why a good installation should not deliver reliable service and duplication of supplies should not be needed for normal manufacturing processes, except where failure could cause consequential loss. More economical ways of carrying out factory distribution should be sought, among them the use of metal-clad switch-fuse gear, totally enclosed air-cooled transformers and, in the larger works, a system of low-voltage mains so arranged that adjacent transformers were supplied from different high-tension feeders. All engineers would welcome designs of switchgear which avoided the use of oil, but satisfactory types of air-break low-tension switchgear were more costly, except for the highest ratings. If, however, money was to be spent in avoiding oil it seemed logical to do so on the high-tension switchgear, where the effect of an explosion was more disastrous. To keep down the cost, more standardisation was essential, so that complete units, such as circuit-breakers, could be mass-produced.

The present practice in the electrical equipment of machine tools was to build in both the motor and the control gear, but considerable maintenance problems were thereby introduced and replacement rather than repair became necessary, thus rendering a considerable stock of spares essential and requiring the maintenance man to be well versed in the idiosyncrasies of a wide range of apparatus. Standardisation of motor frames and of relay and contactor parts should enable the cost of both manufacture and maintenance to be reduced. Variable-speed motors were often run continuously at one speed, so that the cost of the variable-speed equipment was wasted. It was therefore well to make sure that it was really needed and whether the effect could not be attained in some other way. The choice of switchgear for controlling 3·3-kV motors depended on the duty. If operation was infrequent, oil circuit-breakers performed well, but if it was frequent and the making currents were heavy, the higher cost of air-break switchgear or contactors might be justified. Development of the higher ratings of 3·3-kV cartridge fuses was necessary, as they constituted the best way of providing short-circuit protection to back up a contactor.

Where hand tools were in continuous use, those driven by motors supplied from the mains at 50 cycles tended to be bulky and heavy, so that motors with frequencies between 100 and 400 cycles or compressed-air tools were used instead. The disadvantage of the former alternative was that a frequency changer and special wiring system were required, so that its application was restricted to places where the density of use was high. Air motors were simple, but it was not often realised that when electricity was used to drive the compressor the consumption might be from three to ten times that for electrically-driven tools.

Finally, the author pointed out that industry was much dependent on good lighting and that there was still plenty of opportunity for improving the overall efficiency. There was also a need for planned maintenance, and particular stress must be laid on the necessity for safety both on portable tools and on installations generally.

(To be continued.)

Magnimeter Projection Meter.—The Magnimeter projection meter now being manufactured by the Baldwin Instrument Co., Ltd., Dartford, Kent, consists of a standard meter movement with an extended pointer, which traverses a transparent scale. Both pointer and scale are interposed between a light source and the lens of a standard film-strip projector and their images can thus be thrown on to a screen. The meter is connected in the circuit under test, the variations in which can then be observed by a large number of people without darkening the room.

Centenary of James Austin and Sons (Dewsbury), Limited.—The structural-engineering firm of James Austin and Sons (Dewsbury), Limited, who attained their centenary earlier this year, have sent us a copy of their commemorative booklet, 1850-1950: 100 *Years of Progress*. James Austin, the founder, was a native of Leeds who established himself in Dewsbury as a whitesmith with the firm of Harrison and Pagett. He acquired the business in 1850 and, in 1854, transferred it to Batley Carr. Ten years later, he moved to larger premises in New Bridge-street, Dewsbury, and there greatly developed the sale of iron and steel plates and sections, and of saw blades for the cutting of stone. After James Austin died in 1892, the business was carried on by his sons, who took into partnership (among others) Joseph William Wilson, their principal sales representative, who eventually became chairman and managing director. His son, Mr. Arthur Wilson, is the present managing director. In recent years, the firm have greatly expanded the range of their interests, which now includes not only structural engineering and the supply of iron and steel sections, etc., but general engineering of many kinds, carried on in their own Thornhill Iron and Steel Works at Dewsbury, which has been their headquarters since 1927, and in those of their associated companies, Astley Brook and Company, Huddersfield, and A. J. Riley and Son, Batley.

LONDON COUNTY COUNCIL PAINT LABORATORY.

The chemist-in-chief of the Public Health Department of the London County Council is responsible for testing a wide range of samples of many products that are applied in the service of the Council and on behalf of the eight million population of the area. About 10 per cent. of the samples tested are concerned with paints or similar mediums, of which the Council uses 200,000 gallons in the course of each year and on which the annual expenditure approaches 1,000,000*l.* It is therefore imperative that every effort should be made to ensure the purchase of only those products that will prove most economical over a long period. Although the regular inspection of paints has now been undertaken for several years, the facilities for this work have recently been extended by the establishment at the County Hall of a laboratory for this purpose.

The methods employed for the complete examination of a paint are both many and varied, and depend on the purpose for which the particular paint is intended. The principal pieces of apparatus installed in the laboratory are described below; for the most part the tests undertaken are comparative in nature and are devised only with the object of selecting the more suitable product for a given purpose, rather than for the absolute measurement of any physical or chemical property, and this aspect of the work is largely reflected in the nature of the apparatus.

For ascertaining the "finish" or appearance given by decorative paints, and for determining the duration of their drying periods, a paint-drying chamber has been installed. The temperature is closely controlled and maintained steady while a dust-free air current is passed continuously through the chamber. Under such conditions, paint samples can be left to dry out under the conditions of a standardised atmosphere. Painted sample plates can be used for a variety of tests, such as, for example, those carried out in the accelerated weathering machine made by J. B. Marr and Company, Ltd., Twickenham, Middlesex, which reduces the life of a paint from about five years to about 1,000 hours, that is, six weeks. The sample plates are mounted on the internal periphery of a slowly rotating drum (3 revs. per hour) and are subjected during each revolution of the drum, to a dousing in a water spray and then to exposure in the light of a carbon arc. Since variations in the impurities in the water spray would interfere with the test, special provision had to be made for obtaining 25 gallons of distilled water each day. It has proved most economical to tap the main steam supply of the County Hall and to pass the distillate through a series of glass-wool filters to remove the traces of oil.

The resistance of paint films to corrosive effects is measured in a humidity cabinet, in which a high temperature is maintained and in which the paint samples can be exposed to sprays of water, to which may be added either salts or acids to simulate particularly corrosive atmospheres. This apparatus has been obtained, as have several other pieces in the laboratory, from Research Equipment (London), Limited, Wellington-road, Hampton Hill, Middlesex. Three simple, but effective physical tests made on apparatus obtained from this firm are the bend test, the scratch-hardness test and impact test. Flexibility is examined in the bend test, where a sample paint film on hinged plates is bent round the hinge (i.e., mandrels of standard diameters) the 180 deg. bend being made in about one second. The scratch-hardness test measures cohesion of the paint film. A hardened ball-pointed stylus is pressed against the film by a known weight (100, 200 or 500 gm.) and drawn across the film at a fixed speed; the load required to bring about failure is indicated by the stylus penetrating the film and, in so doing, completing an electrical circuit, and the current is recorded by the movement of an ammeter needle. From the load required to cause penetration, taken in conjunction with the ammeter reading (a function of the size of the scratch), the test gives a reproducible record of the strength of the paint film.

The permeability of a paint film is measured by a remarkably simple test. A film of standard thickness is prepared and this is placed over the top of a small cup containing a little water. A sealing ring clamped over the film ensures both watertightness and airtightness. The cup, together with its water content and clamped paint-film cap, is then weighed; successive reweighings give a straightforward indication of the permeability of the paint film. Both viscosity and the density of the paint are measured by conventional methods, although in each case the apparatus has been modified for the particular application. The thickness of a paint film on metal plates is measured by employing its disruptive effect on the field between two induction coils, the change in the current in the circuit being calibrated in terms of paint thickness.

The opacity or hiding power of paint samples is measured because it affects the decision as to whether one or two undercoats will be necessary to obliterate the previous surface; apart from the cost of the materials, the deplorably high cost of applying the paint means that the effective use of only one undercoat, instead of two, gives a saving out of all proportion to the added cost of the materials. A quality allied to opacity, the gloss of a paint film, varies from matt to an enamel finish, and the accurate assessment of loss of gloss under standardised conditions is one of the several means by which film breakdown can be estimated. Both opacity and gloss are measured on a comparator, made by Evans Electroselenium, Limited, Harlow, Essex, using a photo-sensitive cell and a galvanometer, the apparatus being calibrated against a standard black-enamel surface. The washability of paints and distempers is similarly compared in an apparatus—in this instance, made by a member of the laboratory staff—wherein a brush is regularly dipped into water and then dragged across the painted surface, the number of passes required to destroy the surface being a measure of the paint's washability.

The chemical composition of the pigments is derived—in the first instance—quantitatively, by spectroscopic methods. A small sample of the paint is burned and the emitted light passed through a prism, the spectrum being recorded on a photographic plate; by comparison with the standard iron spectrum the presence of even minute traces of elements can be observed. In the hands of an experienced analyst, a fair estimate can be made by this method of the quantity of traces present, although normal chemical analysis by separation is necessary if an accurate determination is required. In company with several other authorities, the Council will not permit the presence of lithopone (an admixture of barium sulphate and zinc sulphide with traces of zinc oxide) in paints to be used for exterior decoration. Although lithopone has enhanced qualities of opacity and flexibility and it is inert to a sulphurous atmosphere, it has the drawback that it tends to blacken when exposed to sunlight before it has dried, or in the presence of lead, when lead sulphide is deposited. For this reason, a standard titration test has been developed and permanent apparatus set up for the regular detection and determination of the lithopone content of paints.

From the many tests to which paints can be submitted in the laboratory, the chemist is able to advise the user departments, that of the engineer-in-chief and of the architect, on the suitability, or otherwise, of a particular proprietary brand of paint submitted by the department for examination. By such examination, it is intended that the Council shall remain a discerning buyer and that the decoration and preservation of the many buildings under their care shall be safeguarded.

FLAMEPROOF BARRIER BOX.—The General Electric Co. Ltd., Kingsway, London, W.C.2, have designed a flameproof barrier box for connecting conduit entering an inflammable from a non-inflammable atmosphere or *vice versa*. It contains four 600-volt 20-25-ampere terminals and is fitted with two 1-in. outlets on both the incoming and outgoing sides. It has been approved by the Ministry of Fuel and Power for use in gases of Groups II and III and has been awarded the Buxton certificate.

LABOUR NOTES.

A TRENCHANT rejoinder to those who have criticised trade unionists for accepting places among the members of the new Iron and Steel Board is made by Sir Lincoln Evans, C.B.E., the general secretary of the Iron and Steel Trades Confederation, in the June issue of *Man and Metal*, the Confederation's official journal. He states that controversy has been deliberately whipped up for purposes that have no real concern for steelworkers' interests and considers that it is all part of the cold war which the extreme left-wing group in the labour movement has been conducting for some time past.

The Confederation will not be stampeded from doing what it believes to be its trade-union job, which is to make secure, as far as it is able, the employment, under the best possible conditions, of its members. He asks if the redundancy problems that will come from future development schemes—the kind of problems that are now being encountered in South Wales—are of no concern to the unions, and if unionists are prepared to allow these matters to be determined by a Board on which trade unions have no place. Sir Lincoln states that the Foundry Workers' Union may be content to leave the controlling of affairs in that section of the industry—the larger part of which has never previously been under any public control or supervision—to a Board representing every interest except that of the trade unions, but the Confederation is not. To the Confederation such conduct would represent a complete abdication of the right trade unionists have always demanded, to have a say in the direction and control of industry.

It has been affirmed, Sir Lincoln continues, that the new Board is a sham. Only experience can prove that. The previous Board, which had less power, did not turn out to be a sham. For the Confederation to have boycotted the Board would have been to run away from its plain trade-union duty. Furthermore, it would not have made sense. For if, on political grounds, the present Government cannot be trusted, that is all the more reason for trade-union participation on the Board, to ensure that the interests of employees are not ignored. How can trade unions with a mixed membership, holding all sorts of political beliefs, function in the kind of world we are living in, where the affairs of industry are becoming more and more intermingled with Government, if political affiliations are to have priority over industrial obligations?

The doctrine that trade unions, for political reasons, should not help industry to become more efficient is too silly for words, and to be charged with disloyalty if one does not accept that view, is sillier still. These loyalty tests produce strange results. When ex-ministers and others associated with the left-wing group are employed as advisers to private firms to make them more efficient, their loyalty is never questioned. Yet, when trade unionists agree to serve on a public Board to supervise private industry, they are denounced as *saboteurs*.

Support for Sir Lincoln was given at a special meeting of the Confederation's executive council on June 12, when a resolution was approved stating that he accepted the appointment to the Iron and Steel Board with the council's approval and consent. The Confederation's policy on denationalisation was unchanged, the resolution continued, but the fact had to be accepted that the decisions of the Board would affect the lives and prospects of 118,000 members of the Confederation employed in the industry. The Confederation could not evade its obligation to its membership by yielding to the criticism and clamour of those who knew little of the industry. It is expected that Sir Lincoln will resign from the general secretaryship of the Confederation, as well as from his posts on the Trades Union Congress, as soon as the date for the Board to commence its operations is announced. His successor is likely to be Mr. H. Douglass, the Confederation's assistant general secretary.

The resignation of Mr. James Owen, one of the two trade-union part-time members of the Iron and Steel Board, from his appointment as general secretary of the National Union of Blastfurnacemen, was made known on June 10, and it was announced that he had requested the union to withdraw his nomination for membership of the T.U.C. General Council for 1954. Mr. Owen's action followed meetings of the union's executive committee, in London, at which the position was discussed. After the meeting on June 10, it was stated that the committee had re-affirmed its decision of last December that the union should participate in the formation of the Board, if invited to do so, provided that such action did not conflict with the policy of the T.U.C.

It was made clear in the statement that the committee had no objection in principle to being represented on the Board. The committee took the view, however, that Mr. Owen could not combine the functions of a full-time trade-union official with even part-time work on the Board, but agreed that he should be free to carry out the duties of one or other of the two posts. Mr. Owen decided to resign from the union's secretaryship and asked that his services should end with the annual meeting in July. It was emphasised that he would leave the union with the goodwill of the committee, and that his colleagues considered his work on the Board to be of national importance.

Complaints that work on the insulated-cargo hold of the Arcadia was being done by shipwrights, instead of by members of their own union, led to the commencement of a strike by some 250 sheet-metal operatives at the Clydebank shipyard of Messrs. John Brown and Company, Limited, on June 1. The men belong to the United Society of Boilermakers, Shipbuilders and Structural Workers, and, after a meeting of the strikers on June 10, other members of the Society employed at the yard ceased work in sympathy. It was announced that more than 1,200 men were then involved. Later, about 800 train drivers, platers' helpers and boilermakers' labourers, not directly concerned in the dispute, were paid off by the company, owing to the dislocation of production which had arisen.

A "stupid strike" was the description given to it by a local official of the National Union of General and Municipal Workers, which looks after the interests of the labourers and helpers. He appealed to the Clyde district committee of the Confederation of Shipbuilding and Engineering Unions to intervene and end the dispute. It was stated on behalf of the firm that everything possible would be done not to add to the number of men suspended, but everything would depend upon how long the stoppage lasted. It was entirely a union matter. A further meeting of the strikers last Monday decided to continue the stoppage.

Delegates to the annual conference of the United Society of Boilermakers, Shipbuilders and Structural Workers, which was held at Eastbourne on Wednesday, Thursday and Friday last week, passed a resolution pledging their full support for the men on strike at Clydebank. They demanded that trade-union officials who have accepted positions on the Iron and Steel Board should resign from the T.U.C. General Council and voted unanimously in favour of a wage increase of 15 per cent. for all adult manual employees in the engineering industry.

The settlement of another demarcation dispute was announced on June 12, at the close of a meeting in York between the central conference committee of the unions involved and representatives of the Engineering and Allied Employers' National Federation. The dispute arose some months ago between the Amalgamated Engineering Union and the National Union of Sheet Metal Workers and Braziers on the question of which organisation's members should operate the new high-power metal press at the Newtownards Works of Messrs. Short Brothers and Harland, Limited, at Belfast, which has been idle since its installation at the end of last year. A decision is understood to have been given in favour of the sheet-metal workers.

ALUMINIUM AS A STRUCTURAL MATERIAL.

By M. BRIDGEWATER, B.Sc.

(*Concluded from page* 765.)

ECONOMICAL DESIGN.

ALUMINIUM is a comparatively expensive material, its cost being almost three times that of steel, volume-for-volume; if it is to compete with other materials, it must be used with the utmost economy. The designer is justified in taking greater pains over the design and using more expensive fabrication techniques in order to save material. The main difficulty presented by this approach is in the design of efficient compression members to minimise the adverse effect that the low modulus has on the load-carrying capacity of struts. In this, the designer is assisted by two important features of HE10WP sections: the versatility of the extrusion process enables complicated sections to be produced for moderate tool costs, and the high resistance to corrosion permits the use of thicknesses as low as 0·080 in. without jeopardising the life of the structure.

The efficient use of the material can best be achieved by the design of special sections for specific jobs, full use being made of the possibilities of the extrusion process to obtain the desired sectional properties. Unfortunately, this entails a large amount of calculation, which is not justified by every design. A large proportion of this work could be overcome by the provision of a range of standard sections, which would be designed both to be efficient and to avoid the various forms of instability. These could be applied directly to ordinary structures, and also used for preliminary schemes on large projects that might ultimately justify their own special sections.

The need for a standard range of efficient sections was realised after the war, and the aluminium industry instigated work at the universities on the various associated theoretical problems. As an immediate step, the British Standard 1161 for aluminium sections was introduced, in which the sections were identical to existing steel sections, with the exception that they had parallel instead of tapered flanges. These sections are generally useful for standard fabrication and satisfy a definite requirement, but it was soon found that they were uneconomical for competitive design and that, furthermore, they were prone to premature failure if used indiscriminately. Many engineers have therefore designed their own range of standard efficient sections which they use for all general work, and it now appears that, independently, they have settled on almost identical sections. This agreement is quite remarkable and suggests that the requirements of an aluminium section are now fully understood and that the knowledge that has been accumulated could well be utilised to design a range of standard sections representing a considerable advance on the current B.S.1161 sections.

Design of Efficient Sections.—The requirements of a standard range of sections are that they should be economical in material and resist the various forms of instability, so that the designer does not need to be preoccupied with these considerations. A range of sections with these features was first suggested by Temple* in 1946 and, in general, present practice has confirmed the soundness of his recommendations. Efficiency can only be achieved by placing the metal as far away from the neutral axis as possible, so that higher moments of inertia and section moduli are obtained for the same sectional area. This necessitates the use of thinner sections than normal, which, without some form of stabilising, would be very prone to the various elastic instabilities. The sections should be stiffened, therefore, by the addition of heavy root fillets, lips, or bulbs, the exact dimensions being governed by the slenderness range over which the sections are to be used.

Optimum efficiency is achieved when all forms of failure—overall buckling, torsional and local failure—occur at the same compressive stress, but as this can only occur at one slenderness ratio the section should be dimensioned so that local and torsional failure occur at the minimum slenderness ratio at which the strut will be used. Such practical considerations as joining, limitations of the extrusion process, and site handling will impose a limit on the minimum permissible thickness and hence on the maximum obtainable efficiency. Recent experience has enabled satisfactory compromises to be made and suitable thicknesses to be established.

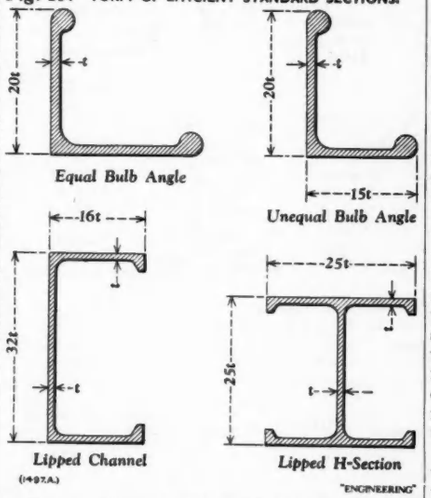
To be of real value, the sections should be such that designers are relieved of the difficult and tedious calculations necessary to predict the occurrence of elastic instability, the critical stresses for the various types being included in the tables of standard properties. With the limited theoretical background, this would necessitate, at present, practical testing in order to substantiate the calculated failing stresses. The most expedient way of achieving this would be to employ geometrically similar ranges of sections, so that all the sectional properties could be expressed as a function of the thickness:

$$I = k_1 t^4, \quad J = k_2 t^4, \quad Z = k_3 t^3,$$
$$A = k_4 t^2, \quad r = k_5 t,$$

where k is constant for sections in any geometrically similar range.

Crippling stresses due to local or torsional failure can then be expressed as a non-dimensional ratio independent of section size, the critical stress being the same for all members in the range. Only a limited number of sections would have to be tested to establish the failing stresses of all other members. A further advantage would be gained, as designers could use section sizes intermediate in the standard range, without having to carry out the calculations on either sectional properties or instability stresses; the saving in material obtained by the use of the correct section would generally be sufficient to offset the cost of the comparatively inexpensive new extrusion die.

Fig. 10. FORM OF EFFICIENT STANDARD SECTIONS.



METHODS OF DESIGN.

The precise nature of the requirements for the design of an efficient section varies with the type of section under consideration, and the following short review is intended to give some indication as to the most suitable method of designing each type.

Equal Angles.—Without any stiffening, plain equal angles would become torsionally unstable with a leg-to-thickness ratio of about 12; but, as thinner legs are required for economic design, it becomes necessary to stabilise the section against torsional instability so that the full strength in overall buckling can be realised. This can be achieved, as previously shown, by the addition of bulbs and a heavy fillet, the additional metal being so proportioned between the fillet and bulbs as to give the greatest minimum moment of inertia. Experience has shown that a leg-to-thickness ratio of about 20 : 1 gives the best practical proportions, and sections of this type are, in fact, being used extensively in current aluminium design. They are normally employed in lattice work where the slenderness ratios are over 50, so that the size of the stabilising bulbs and fillets should be just sufficient to prevent the onset of torsional instability at this slenderness value. The precise form of the bulb and fillet is a moot point and is largely a question of the designer's own inclination, but it has been found that bulbs with a $3t$ diameter and fillets with a $3t$ radius are about correct to prevent torsional failure occurring at slenderness ratios down to 60.

Unequal Angles.—The same general principles apply to the design of unequal angles, though the theory is somewhat complicated by the unsymmetrical nature of the section, which causes general interaction of torsion and flexure. For light lattice work, it has been found that double unequal angles are extremely economical and, therefore, lattice design should be undertaken with this in mind. The angles should be proportioned in such a manner that, when they are used in pairs about a gusset, the moment of inertia is the same in both principal planes. This can be achieved approximately when the leg lengths are in the ratio 3 : 2, and, for overall efficiency, the ratio of the longer leg to the thickness should be about 20 : 1, as in the case of the equal angle. The amount of stiffening in this case should be sufficient to prevent torsional instability occurring to a single angle when the composite strut is stitched at the third points, and is roughly the same as that for the equal angle.

Channels.—The main uses of channels are as purlins, or as double-battened members; for both applications, the most reasonable and convenient proportions are for the depth to be twice the width. Local flange buckling is likely to occur so the flanges should be stiffened by the addition of lips and fillets. The precise stiffening effect of the lips does not seem to be known, but it is generally agreed that the addition of small lips will have a large effect on the buckling load. Minimum thicknesses in this case are generally governed by the extrusion process, and sections with webs with a depth/thickness ratio of about 30 and flanges with a width/thickness ratio of about 15 appear to be the thinnest that can readily be manufactured.

I-Beams.—For an I-beam the problem is similar to that for a channel, and the main requirement is to stiffen the flanges against local buckling. I-beams often make convenient diagonal bracing members where double-member chords are being used. In cases of this kind, where they are used as struts, the sections should be squat so that their momental ellipse is more circular than that for normal I-beams. If the flanges become too deep, difficulty will be experienced in riveting; the most reasonable compromise appears to be that where the depth is equal to the width.

Fig. 10, herewith, gives general impressions of the various types of sections. It is difficult to compare the relative efficiencies of these proposed sections and the existing B.S.1161 sections, as they will depend upon both the slenderness ratios and the loads. Comparison of the equal bulb angle and the lightest B.S.1161 angles shows that, for equal areas, there will be a gain of approximately 25 per cent. in the minimum radius of gyration. This enables weight savings of the order of 20 to 25 per cent. to be achieved by the replacement of B.S.1161 sections by the light bulb-angle. Corresponding savings should be achieved in compression for the unequal bulb angles and lipped channels, and the use of the lipped channels in bending should result in about a weight saving of 20 per cent. over the B.S.1161 channels.

If a range of sections were produced on these lines, it would enable designers to produce efficient light-alloy structures without having to worry about the instability problems which appear to be a major obstacle in aluminium design. These sections, coupled with the present B.S.1161, would be adequate for ordinary purposes and, where projects called for special sections, the proposed range would offer a convenient basis from which these specialised members could be evolved.

JOINING.

One of the major problems confronting the user of a new structural material is that of joining, as no two materials are alike and, with each, fresh techniques have to be evolved. Successful joining

* *Handbook of Structural Design in the Aluminium Alloys*, by J. E. Temple (1947).

of aluminium has proved particularly difficult, and extensive research has been required to solve the many problems. The very resilience which enables aluminium structures to absorb impact loadings prevents the cold-forming of standard large-size rivet heads, and the different characteristics of the joint itself has necessitated the verification of existing design rules. New techniques have also had to be developed for welding, and metallurgical and practical problems solved before cheap reliable welds could be obtained. Sufficient progress had been made on these problems for the Aluminium Development Association to hold, in 1952, a highly successful symposium on "The Riveting and Welding of Large Aluminium Structures," to which reference has been made. The aircraft industry is making progress with the use of new synthetic-resin glues for joining aluminium and it may be that, ultimately, this technique will also find a limited place in general structural practice.

Riveting.—Up to the present, the most satisfactory method of joining aluminium structures has been by riveting. In early aluminium structures, hot-driven steel rivets were employed, but these are not considered entirely suitable because of the danger of bimetallic corrosion and the increased maintenance necessitated by the painting of the rivet heads. The increasing use of aluminium for structures of large size has created a demand for aluminium rivets from $\frac{1}{2}$ in. to 1 in. in diameter, and research work on this problem has yielded much valuable information, from which a British Standard for large aluminium rivets is now being compiled. So far, work has been concentrated on the cold-driving of rivets, as it was thought that the narrow temperature range necessary for successful hot-driving, and the high rate at which the rivets lost their heat to the surrounding metal, would offset any advantage that hot-driving offered.

There are three main rivet alloys, N6M, H10WP and H13T, and present opinion appears to favour the use of N6M or H13T. Typical properties of these alloys are given in Table III, herewith. It can be seen that there is very little difference between the ultimate shear strengths of any of the alloys, either for the rivet stock or the driven rivets, and ease of driving is generally the deciding factor in the choice of material.

Fig. 11. SUITABLE HEADS FOR ALUMINIUM RIVETS.

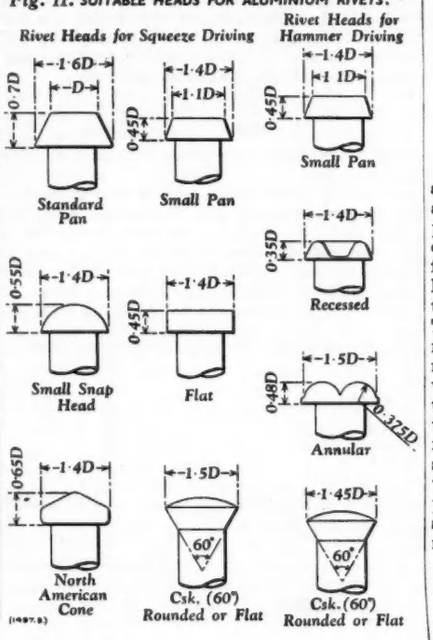


TABLE III.—PROPERTIES OF RIVET ALLOYS.

Alloy.	0·1 Per Cent. Proof Stress, Tons per sq. in.		Ultimate Tensile Stress, Tons per sq. in.		Elongation, Per Cent., on 2-in. Gauge-length.		Ultimate Shear Stress, Tons per sq. in.	
	BS.1476 (min.)	Typical.	BS.1476 (min.)	Typical.	BS.1476 (min.)	Typical.	Typical Rivet Stock.	Typical ½-in. dia. squeeze-driven Rivets.
N6M	8	9	16	18½	18	27	12	13·0 (single shear)
H10WP ..	15	18	18	20	10	13	14	14·5 (single shear)
H13T	—	10	(BS.1473) 17	19	—	20	12½	13·4 (single shear)

The power required to close a cold aluminium rivet head is greater than that for the equivalent hot-steel rivet, and this has led to a careful study* of the influence of the size and shape of head on forming pressures, so that suitable heads could be evolved for closing with standard equipment. New smaller heads have been developed which can be closed up to $\frac{7}{8}$ in. rivet diameter and which will fully fill the holes, provided that the hole clearance is $\frac{1}{16}$ in. or less. For squeeze-riveting, the North American cone and the small pan are favoured, due to the relatively low pressures required for closing; but greater difficulty has been experienced with pneumatic riveting, and special recessed heads had to be developed before rivets $\frac{7}{8}$ in. in diameter could be closed with standard tools. Details of recommended heads for both squeeze and pneumatic driving are shown in Fig. 11, herewith.

More recent experimental work has shown that there may be a case for reverting to hot-driven aluminium rivets. Mr. F. J. Walker, of Head, Wrightson Aluminium, Limited, reported at the recent Aluminium Development Association Symposium that N6M rivets $\frac{7}{8}$ in. in diameter could be hot-driven to form a recessed head in 15 to 20 seconds, and that consistent shear strengths of 14 tons per square inch were obtained. Further work is being carried out on hot-driving, and its outcome may appreciably affect future joining practice.

The behaviour of riveted joints under load and the mechanism of load transference have always been of vital interest to engineers, and it is natural that investigations should have been carried out on the performance of aluminium joints, which differ substantially from steel in their characteristics. The smoothness of the aluminium surfaces gives a low coefficient of friction, which, coupled with the absence of clenching pressures from cold-driven rivets, results in a frictional restraint in the joint which is only one-tenth that experienced in an equivalent steel joint. Almost from the onset, the load is taken by shear in the rivets and not by friction in the plates, but Francis* has shown that, though the mechanism of load transference is vastly different from that in steel, the ultimate strength of an aluminium joint can safely be estimated by established methods. Redshaw† gave specific recommendations to the Aluminium Symposium on the design of aluminium joints. These are of sufficient interest to be quoted below in full.

"In general, the assumption of equal load distribution among the rivets of a joint is sufficiently accurate for joints which have the following necessary characteristics:

(1) Compatible with static strength, as ductile a rivet alloy as possible should be used. HE10WP is a most satisfactory alloy in this respect.
(2) Any plate alloy used should have a ratio of proof to ultimate stress sufficiently high to prevent plasticity of the plates within the joint before the maximum load is reached. The best of the alloys considered was HE10WP.
(3) The length of the joint should be as small as possible: i.e. as few rivet rows as possible for a given size of joint.
(4) Rivet pitches should be as small as practicable.
(5) Rivet-diameter/plate-thickness ratio should be such that the rivet has as high a ductility as possible without any loss in rivet strength occurring. From the small amount of experimental evidence available for NE6 rivets a d/t ratio of approximately 1·5 appears to be the best."

Welding.—An attractive and often economical alternative method of joining is welding, and the advances in technique are such that it is now possible to weld HE10WP with either the argon arc or the metallic arc, and to achieve perfectly satisfactory results. Although reliability of the weld has now been achieved, there is still little information available on the behaviour of a welded joint. The high temperature associated with welding reduces the strength of the parent metal and results in a region of comparatively brittle material, which may appreciably alter the mechanism of load transference within the joint. Until further information is forthcoming on this, little progress can be made in the widespread application of welding to structures. There is no doubt, however, that welding will be ultimately of great use, and its potentialities have already been amply demonstrated by its extensive use in the fabrication of military bridging equipment.

RECENT EXAMPLES OF ALUMINIUM STRUCTURES.

A few examples of recent aluminium structures will illustrate the foregoing sections of this review, and will show that a solid background of practical experience is being gained. At present, aluminium is comparatively expensive, and some definite advantage must be gained from its special properties to justify its use. Its low weight is of great benefit in moving structures, such as bascule bridges, overhead travelling cranes and excavator booms. This high strength/weight ratio is also an advantage in large-span buildings and bridges as it reduces the dead loading, which is often a high proportion of the total loading, and thus enables aluminium construction to become cheaper than other forms. The low maintenance resulting from the higher corrosion resistance of HE10WP has led to aluminium being used in steelworks, gas works, and other places where excessive maintenance is required if steel work is used.

Fig. 12, opposite, shows the three-bay aluminium hangar under construction at London Airport. It was designed and built by Structural and Mechanical Development Engineers, Limited, and each bay has a clear span of 125 ft., a length of 110 ft., and a clear height of 30 ft. The main arches, which are pinned at the base, are of the portal type and are built up from double-battened channels. A further hangar, of 250 ft. span, is being built by the same firm for the de Havilland Aircraft Company, and it is understood that, in this case, aluminium was found to be the cheapest form of construction.

The real future of structural aluminium may well lie in the sphere of large-span buildings and bridges, and it is hoped that engineers will be quick to realise its potentialities in this field. It is ironic that many large structures are not likely to be contemplated until experience has been gained on smaller ones, and that these are unlikely to be built except where there are special circumstances to give economic justification for their construction. Great importance should be attached, therefore, to any examples that can give guidance on the per-

* "The Properties and Driving of Large Aluminium Rivets," by J. C. Bailey. A.D.A. Symposium on Welding and Riveting of Large Aluminium Structures, November, 1951.

* "Investigations on Aluminium-Alloy Riveted Joints under Static Loadings," by A. J. Francis. Contribution to Symposium promoted by the Colston Research Society (Butterworth's Scientific Publications, Limited (1949)).

† *Loc. cit.*

ALUMINIUM AS A STRUCTURAL MATERIAL.

(*For Description, see Page* 793.)

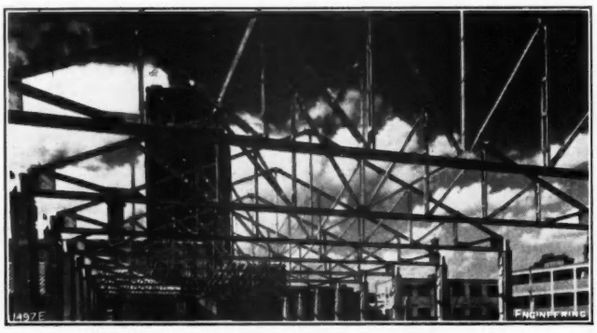


FIG. 14. ROOF TRUSSES OF DOUBLE-BATTENED CHANNEL CONSTRUCTION.

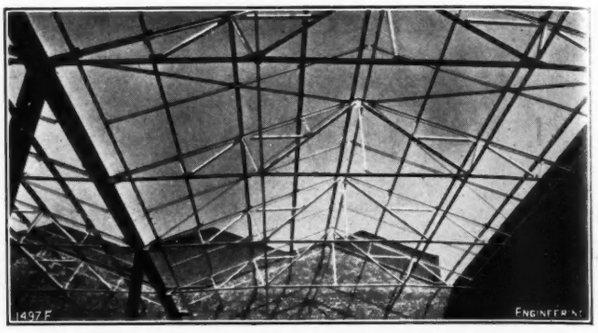


FIG. 15. ROOF TRUSSES OF DOUBLE-ANGLE CONSTRUCTION.

FIG. 16. TRIANGULAR ROOF AT FACTORY OF AERO RESEARCH, LIMITED.

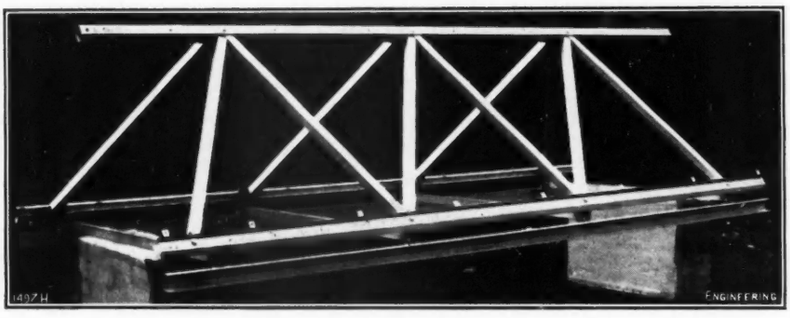


FIG. 17. SECTION OF TRIANGULAR ROOF TRUSS.

FIG. 18. GREAT-CIRCLE BEAMS IN THE DOME OF DISCOVERY.

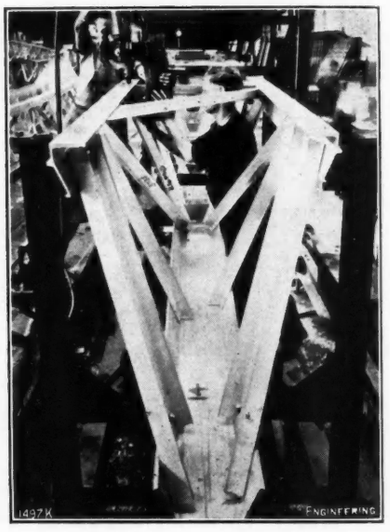


FIG. 19. TRIANGULAR-SECTION BEAMS FOR DOME OF DISCOVERY.

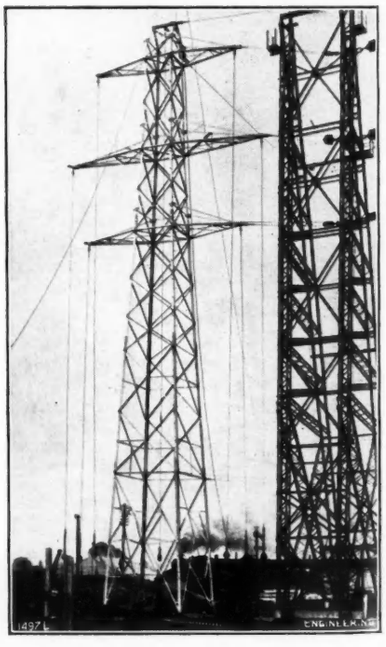


FIG. 20. 132-KV TRANSMISSION TOWER (UPPER HALF OF ALUMINIUM) UNDER TEST.

(*To face page* 795.)

ALUMINIUM AS A STRUCTURAL MATERIAL.

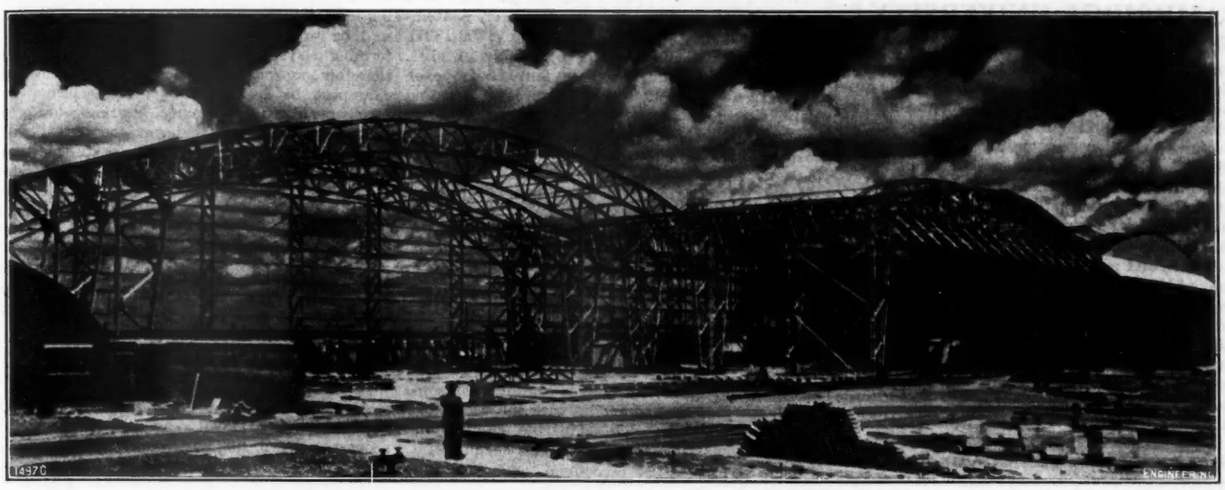


FIG. 12. ALUMINIUM HANGAR AT LONDON AIRPORT.

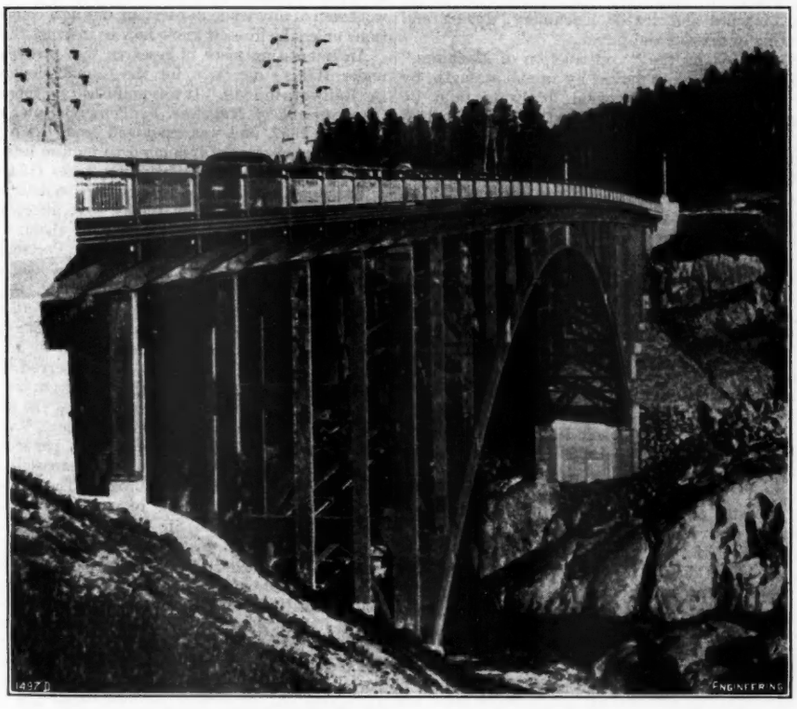


FIG. 13. THE ARVIDA ALUMINIUM BRIDGE.

formance of large aluminium structures and this is a reason for including the Arvida aluminium arch bridge, recently built in Canada (Fig. 13). The Arvida bridge, which was built by the Dominion Bridge Company, of Montreal, has a clear span of 290 ft. to the skewbacks and a vertical rise of 47 ft. 6 in. The alloy used is copper-bearing, with a 0·1 per cent. proof stress of 22 tons per square inch and an ultimate tensile strength of 27 tons per square inch. A large amount of experimental work was carried out during its design and one of the practical outcomes of this work was the development of the recessed rivet head. It is planned to conduct exhaustive field tests on the bridge under various conditions of loading and temperature, over a long period, which it is hoped should yield valuable information.

Great ingenuity is required in the design of aluminium structures to offset the effects of low modulus and relatively high material cost. The extent to which the designer can resort to increased fabrication and design work in order to economise on material is problematical, and can only be learned by hard experience. Two types of construction, double battened channels and double unequal bulb angles, have both been used extensively to achieve economical design, and, though double battened channels produce the lightest design, it now appears that the fabrication costs are too high and that double bulb angles are the more economical type of construction.

Figs. 14 and 15, on Plate XXIV, show these two forms of construction employed in roof trusses of 40 ft. span, both being constructed by Structural and Mechanical Engineers, Limited.

To offset the low stiffness, it is advantageous to use redundant framework where possible, the versatility of the extrusion process assisting the designer in this. Two examples will illustrate this point: the first, Figs. 16 and 17, Plate XXIV, show the 42-ft. span triangular roof truss designed by Messrs. Ove Arup and Partners for the new factory of Aero Research, Limited, at Duxford. A clever use of extrusion has enabled the designer in this case to achieve a clean and efficient truss. The second example, Figs. 18 and 19, Plate XXIV, is the great-circle beam of the recent Dome of Discovery, now demolished. Here again a triangular truss was adopted, the construction being greatly simplified by the employment of special sections.

The adoption of bulb angles and lip channels is new to structural practice and, as yet, comparatively little experience has been gained on their performance. A certain amount of laboratory test work has been carried out, and, no doubt, will be intensified as their use becomes more widespread. For this reason, the illustration (Fig. 20, Plate XXIV) of a 132-kV aluminium transmission tower under test is of special interest. The top half of the tower was designed in aluminium alloy by Blaw Knox, Limited, for the British Electricity Authority, because the superior corrosion resistance of HE10WP is expected to eliminate the maintenance of the top half of the tower, avoiding costly shut-downs. The tower was designed with bulb-angle legs and cross arms, and tubular bracings, and was assembled with HE10WP bolts. It was subjected to the British Electricity Authority's standard tests and, with the exception of one diagonal bracing member which broke at 100 per cent. test load, the tower performed extremely well. The broken member was replaced and the test was continued until failure was ultimately achieved at 115 per cent. load by the buckling of one of the steel leg members.

This review has dealt mainly with the problems associated with aluminium design that are not normally encountered in general structural practice. This has been deliberate as, before it is possible to achieve real economy in design, it is necessary to understand the structural properties and limitations of the material and how the latter may be overcome. Most structural problems are, of course, common to all materials and the same solutions apply to either steel or aluminium and need no further discussion here. For the most part, therefore, aluminium design follows conventional practice and new methods are only needed for the solution of the problems outlined.

The author is indebted to the following firms, etc., for the illustrations stated: Aluminium Laboratories, Limited (Fig. 4); Building Research Congress (Figs. 7 and 9); Northern Aluminium Company, Limited (Figs. 10, 11 and 20); Structural and Mechanical Development Engineers, Limited (Figs. 12, 14, 15, 18 and 19); Aluminium, Limited (Fig. 13); Ove Arup and Partners (Figs. 16 and 17); and Blaw Knox, Limited (Fig. 20).

THE EARLY TEACHING OF ENGINEERING IN CAMBRIDGE UNIVERSITY.*

By E. G. STERLAND, M.A., A.M.I.Mech.E.

THE teaching of engineering in Cambridge goes back farther than would be expected from the mere statement that the chair of Mechanism and Applied Mechanics was founded in 1875. In fact, courses of lectures on engineering were given as early as 1796. The persons who were engaged in this teaching were the Jacksonian Professors, who held their chair under the Will of Richard Jackson of Tarrington, Hertfordshire, who died in 1782. This rather curious Will gives lengthy instructions as to the election and payment of the holder, the subject-matter of the lectures he is to give and the manner in which they are to be given. The electors are enjoined that they shall appoint ". . . such person as they shall in their own proper judgments look upon to be the best qualified by his knowledge in Natural Experimental Philosophy and the practical part thereof, and of Chymistry, to instruct the students in the said University in the said Sciences . . . which Lecturer . . . shall . . . read publicly a course of lectures on Anatomy, Animal Economy, Chymistry, Botany, Agriculture or the Materia Medica at large, with due and proper exhibitions of the subject to be read upon . . . together with proper Dissections, Analyses and Experiments . . . as may compose a due series of experimental lectures and such practice as may truly thence result for confirmation of what is know at present, or for making further discoveries in any branch thereof as may best tend to set forth the Glory of Almighty God, and promote the welfare of mankind, by making further progress in the practice of physic or agriculture, and the investigation of the relative properties of various earths, sands, clays, marls and the like to each other, so as they best may answer the growth of useful vegetables therein, and also in a more precise investigation of what is or may hereafter be part of the Materia Medica . . . and here it is my serious request that the said Lecturer will in this Disquisition have an eye more particularly to that *opprobrium medicorum* called the gout . . ."

In a second codicil to his Will, dated July 5, 1781, he gives further instructions: "As my design in founding this Lecture is the promotion of real and useful knowledge, my opinion is, that this cannot be done to any good purpose by mere reading a Discourse or Disquisition or Essay, but shewing and doing something in the way of experiment upon the subject undertaken to be treated, and my intention in this being to lead young persons by the most easy, natural and as much as may be geometrical method of conducting these enquiries into the properties and uses of natural bodies, whether mineral, vegetable or animal, and their relative effects upon one another . . ."

His particular reference to the gout is explained by the following passage, also from the codicil: "In the year 1760, after being ill of the gout, by drinking some beer which proved to be a little stale, it seized my stomach, and although Dr. Ash was employed, . . . it continued for ten weeks, without intermission, by fits indeed, but in the main very bad, till I was at death's door, so that at last he ingenuously said, 'Bath, Buxton, or the grave.' I chose Buxton, and by drinking a small quantity of water at the spring head, in three days' time my pains went gradually quite away."

The first holder of the Jacksonian Professorship was Isaac Milner (1750-1820), who began life as a weaver's apprentice, was sent to Cambridge by the generosity of his elder brother, Joseph, and finally became President of Queens' College in 1788. In these days, professors published a synopsis of their lectures in the form of a book, sometimes interleaved with blank pages so that their students could make notes. Milner published two such volumes, the first being lectures purely on chemistry and the second on "natural philosophy," including mechanics, properties of matter, heat, optics, electricity and magnetism.

Milner resigned in 1796, and was succeeded as Jacksonian Professor by Francis James Hyde Wollaston (1762-1823). His interests were purely chemical, and his lecture courses as published were entirely on this subject. However, contemporary with him was William Farish (1759-1837), who was elected Professor of Chemistry in 1794. Farish's only publications are four books, each entitled "Plan of a Course of Lectures on Arts and Manufactures, more particularly such as relate to Chemistry," and dated, respectively, 1796, 1803, 1813 and 1821. These books all follow the same pattern, the lectures being divided into four parts.

Part I, "Metals and Minerals," covers elementary geology; mining, including draining and ventilating; smelting of iron; "urging the fire by a combination of forcing cylinders"; casting; moulding; boring; malleable iron; forging; rolling; converting iron into steel; proposed method of making steel immediately from the ore; case-hardening; tempering; and the mining and metallurgy of lead, tin, copper, silver and gold, and alloys such as pewter, type metal, bell metal and brass. Coal mining is considered in some detail, and this Part concludes with the technology of natural materials such as marble, stone, slate, clay, flints, glass, pottery and various chemicals.

Part II is entitled "Animal and Vegetable Substances," and begins with a discussion of agriculture; land drainage and "engines for draining low lands." It goes on to discuss timber, vegetable oil, whale oil, fishery, leather, saccharine juices, rum, textiles and textile machinery, dyeing and printing of textiles and paper.

Part III is on the "Construction of Machines," and covers "engines moved by animal strength, by springs or weights, by wind, by water and by steam." Windmills are discussed at length, including "experiments to determine the force of the wind." After some remarks on water-wheels, the lectures go on to the steam engine, which is fully treated, including the boiler, "gages," the choke valve, the safety valve, the jet, regulation of the steam and jet valves, the condensing cylinder and air-pump, sun and planet and the fly-wheel, and finally "observations on the estimate of the force." Then follow items which to-day would fall in the category of Mechanics of Machines, such as cog wheels, bevils, the action of cogs on one another, "of striking in and out of geer," gudgeons and brasses, screws, racks and cams, "on the conversion of quick motions into very slow ones," the dividing plate, screws cut upon the lathe, and by stocks and dies. This Part concludes with lectures on presses, cranes, lifting jacks and "the application of models to large works."

Part IV deals with waterworks and navigation and treats aqueducts, forcing pumps, canals, tunnels, reservoirs, locks, the caisson, graving docks, dredging of rivers, harbours, piers and quays. Then follow lectures on the construction of vessels, experiments on the stability of floating bodies, the metacentre, experiments on the resistance of water, the proper form of ships, masts, yards, sails and cordage. Farish was elected Jacksonian Professor in 1813, on the resignation of Wollaston, and continued in office until 1837, when he was succeeded by Robert Willis.

Willis was born on February 27, 1800, and was the son of Dr. Robert Darling Willis, physician to George III. He entered Gonville and Caius College in 1822, and was elected to a Fellowship in 1826. Willis had a great interest in subjects in which pure mathematics were blended with physics, and in matters connected with mechanisms. His first publication, dated 1821, is entitled "An Attempt to Analyse the Automaton Chess Player of Mr. de Kempelon." In this book he shows that this machine was in fact spurious and that it was operated by a man of small stature secreted within the apparatus. His studies ranged over a very wide field. Early papers to the Cambridge Philosophical Society were on "Vowel Sounds and on Reed Organ Pipes," 1829, and on "The Mechanism of the Larynx," 1832. In 1830 he was elected a Fellow of the Royal Society. On being elected Jacksonian Professor, he carried on his predecessor's work, but with more particular reference to mechanisms. He published his *Principles of Mechanism* in 1841.

Willis evidently had a good appreciation of the requirements of practical engineering, in addition to his academic knowledge of mechanisms. In a lecture entitled "On Machines and Tools for Working in Metal, Wood and Other Materials," delivered in 1852 after the Great Exhibition, he says: "In forming a system of instruction for practical men, therefore, we may, by a more practical selection of examples, be enabled to teach the principles of mechanics, without greatly altering our present methods. It is true that our theoretical writers are rapidly introducing examples of the actual machinery of our own time into their systems, still these books are necessarily rather intended to teach machinery to mathematicians, than to teach mathematics to mechanists. It may be remarked that, at least in one branch of mechanics, the "strength of materials," the value of theoretical and experimental science has been fully recognised by practical engineers, and the Britannia bridge may be quoted as a triumphant example of the advantages that arise when theory and practice go hand in hand."

He concludes the lecture as follows: "In machinery we have to deal with every kind of material, and to avail ourselves of the peculiar properties of all, in their appropriate places; and thus a skilful engineer should be familiar with every kind of mechanical manipulation and material, from a sheet of card paper to an iron bar, and ought to know as well how to hem a pocket-handkerchief as to rivet a boiler. It is of no use for him to employ workmen of any trade in carrying out new combinations unless he himself know how to instruct them."

An interesting piece of research was carried out under Willis's direction for the Commissioners of the Railways in 1849. It was published as Appendix C to *Strength of Materials*, by Peter Barlow, published in 1867, and was extracted from the report of the Commissioners appointed to inquire into the application of iron to railway structures (1849).

The objects of the experiments were to determine whether the deflections of bridges were affected by the velocity of loads moving along them. The first set of experiments was carried out in Portsmouth Dockyard, the apparatus consisting of a length of track approached by a ramp at 45 deg. to the horizontal, down which a trolley could be allowed to run. What seemed adequate precautions were taken to ensure that the trolley moved on to the test bar without jolting. It was observed after numerous experiments that the deflection at the centre of the test bar was several times the static deflection caused by the stationary trolley. Various speeds were used, from 15 ft. up to 43 ft. per second. In every case, the velocity was increased progressively until the test bar broke. These results appear surprising in the light of present knowledge. In particular, the late Sir Charles Inglis, in his book *Vibration of Bridges*, estimated that the increase in the deflection due to a load moving at speed could not exceed the static deflection by more than one half per cent.

After these experiments, tests were made upon several actual bridges, in which it was found that the results in no way compared with those of the Portsmouth ones in that the increase in deflection due to the travelling load was very much less than had been observed in the experimental results. Willis interested G. G. Stokes in the problem, and Stokes's investigations were embodied in a paper to the Cambridge Philosophical Society, in 1849, which showed that the "trajectory of a body moving across a bridge is unsymmetrical with respect to the centre of the bridge, the maximum depression of the body occurring beyond the centre." Willis devised an ingenious apparatus to determine these trajectories experimentally and gave curves showing these experimental results. He also discussed the effects of the inertia of the bridge.

Willis's was a many-sided personality. In addition to his work in mechanisms and engineering which has been outlined, he was a great expert on medieval buildings and wrote a number of architectural histories of cathedrals such as Canterbury, Chichester, Glastonbury, etc. He was called in as a consultant by the Dean and Chapter of Hereford Cathedral in 1842, to advise them on repairs which were necessary to the fabric. In the course of his studies of ancient buildings he became an expert

* Address delivered to the Newcomen Society at their Summer Meeting in Cambridge, May 29, 1953. Abridged.

on medieval manuscripts and contributed a paper on "Architectural Nomenclature of the Middle Ages" to the Cambridge Antiquarian Society in 1843. In all, he published nearly 50 books and papers over a period from 1821 to 1870. He died in 1875.

On Willis's death, considerable discussion took place in the University as to the future of the Jacksonian Chair. On March 8, 1875, the Council of the Senate reported to the University as follows: "Since 1837 the Chair has been filled with much distinction by Professor Willis, who, following the direction partly given by his predecessor, lectured chiefly upon subjects connected with Mechanism. The Council are of the opinion that the practice of this Professorship should be brought into closer conformity than heretofore with the general object indicated in the terms of the foundation. They are, moreover, of opinion that it will be advantageous to the University, as well as in direct conformity with the design of the Professorship, that the lectures of the Professor should be directed hereafter, at least in part, to the illustration and advancement of the knowledge of some branch or branches of Applied Physics. With a view to this they recommend that the Jacksonian Professor shall be an *ex officio* member of the Board of Natural Sciences Studies, and that he cease to be an *ex officio* member of the Board of Mathematical Studies."

This report was discussed on March 16, 1875. The discussion revealed that, while the University greatly appreciated the value of Professor Willis's lectures on mechanism, they could find no reference to this subject in Jackson's Will. Dr. Campion said that "One thing he defied any one to find in the Will, and that was lectures in Mechanism. Such lectures were very necessary, but they ought not to be supplied by rubbing a sponge over the Will." Mr. Hort said: "Economic Chemistry in the largest sense of the words would be the most central carrying out of the purposes of the Will, but there was also to be considered the tradition of lectures in Mechanism. If the instruction in Engineering was abolished, an existing branch of study, capable of large expansion would be destroyed: if the Professorship was appropriated to Engineering, an act of violence would be done on the founder's Will. Either there must be two Professors, or one Professor must combine the two works."

Although some ten speakers took part in the discussion, not one voice was raised to decry the teaching of Engineering. On the contrary, all who referred to it did so in terms indicating their approval of such study in the University. The provisions of the Council's report were ratified on March 18 by 31 votes to 16.

(To be continued.)

THE LATE BRIGADIER J. B. HICKMAN.—We regret to record the death of Brigadier John Burfield Hickman, C.B.E., M.C., which occurred at Camberley, Surrey, on Wednesday, June 3, at the early age of 54. Brigadier Hickman was educated at Southall County School and at Cambridge, and, after attending the Royal Military Academy, Woolwich, was gazetted to the Royal Artillery in 1917. He transferred to the Royal Corps of Signals in 1923 and served with them during the early part of the 1939-45 war. Subsequently, he acted as Director of Telecommunications Research and Development at the Ministry of Supply and became managing director of British Telecommunications Research, Limited, on its formation. He was appointed a Commander of the Order of the British Empire and was awarded the Military Cross for his war services.

NEW REVIEW OF SCIENTIFIC FILMS.—The first issue of a new quarterly publication, *Scientific Film Review*, has recently appeared. The output of scientific films is now considerable, and many users and other interested persons will be glad to have this critical review of new films dealing with industry, agriculture, medicine and scientific subjects. The information given for each film includes a brief statement of its content, a critical review prepared by the appraisal panels of the Scientific Film Association, screening time, and a coded statement indicating whether it is "recommended," "suitable," or "unsuitable" for each of the following categories: higher education, adult training, specialised audiences, scientific film societies, and general audiences. The review is published as a supplement to the *Monthly Film Bulletin* of the British Film Institute, and is prepared by the Scientific Film Association, from whose general secretary (164, Shaftesbury-avenue, London, W.C.2) specimen copies can be obtained.

ASPECTS OF NUCLEAR FISSION OF INTEREST TO FOUNDRYMEN AND METALLURGISTS.*

By E. W. COLBECK, M.A., F.I.M.

I INTEND to deal with the subject I have chosen under a number of main headings, which are briefly as follows:

(i) Non-destructive examination by means of radioisotopes.
(ii) The use of radioisotopes as tracers in metallurgical processes and in physical metallurgy.
(iii) Nuclear energy as a source of power.
(iv) Some problems connected with constructional materials for atomic piles.

NON-DESTRUCTIVE TESTING.

Of the three types of discernible radiation emitted from radioisotopes, only gamma rays, which in nature resemble exactly the familiar X-rays, penetrate metals sufficiently to be useful for the radiography of castings. Though in the course of my description of gamma radiography I shall claim that the advent of these isotopes is causing something approaching a revolution in technical foundry control, we must not lose sight of the fact that radiography is not a new technique. During the past ten years X-ray equipment has been extensively used for the non-destructive testing of steel castings—especially aircraft castings upon the soundness of which depend the lives of pilots. A well-known casting of this type is shown in Fig. 2, on page 798, while Fig. 3 shows a typical radiograph taken of such a casting, which is an aeroplane undercarriage pivot bracket. In Fig. 1, on page 798, is shown the most modern method of radiographing these castings. They are seen jigged with fixed angulation for simultaneous radiography by a central radioisotope source of gamma radiation.

Even gamma radiography, however, is not entirely new. Its potentialities have long been appreciated because of the ready portability of the necessary equipment for site radiography of heavy castings and because one can put gamma sources at inaccessible places within castings where it would be impossible to position an X-ray tube. In the laboratories of Hadfields Limited, we have, in fact, been using natural radium and radon gas sources of gamma rays for the last five years. Radium tends to give somewhat inferior radiographs owing to the relatively large sizes of sources of adequate strength. Radon gas sources have the disadvantage of a very short-lived activity, the half-life being only just over three days. The half-life is the period of time in which a radioactive substance decays to half its original strength. According to the physical laws of radioactivity this half-life is quite independent of source strength and is a characteristic of particular radioactive isotopes.

By the use of radioisotopes concentrated sources of gamma radiation with reasonable half-life values are obtainable. Even so, the choice is limited, but cobalt 60, for example, a pile product has a half-life of over five years and the activity per unit source volume can be made more than ten times that of the best value for radium sources. As more powerful neutron densities become available in newer piles, this factor will be further improved. Cobalt 60 is, however, not the solution to all radiographic problems in the foundry. Its very penetrating radiation, corresponding roughly to an X-ray tube operating at a peak voltage of 1·8 million volts, makes it very suitable for radiographing steel sections from about 2 in. to 8 in.; but the relative ease with which these rays penetrate less dense metals or thinner sections of steel renders cobalt 60 unsuitable for their radiography. After all, we must remember that it is the absorption in the metal which enables us to differentiate between sound and unsound areas. As an example of an isotope emitting softer radiation (corresponding to an X-ray tube peak voltage of about 900 kV) I would like to mention caesium 137. This is a relatively rare fission production of uranium 235 and has a half-life time of more than 30 years. I hasten to add, however, that this isotope is only in the research stage, but we have good reason to believe that experiments with it will prove successful.

One of the most important advantages that arises from the availability of the new sources of gamma rays is an economic one. Until two or three years ago a foundry wishing to install suitable apparatus for radiographic examination was faced with the alternative of buying a relatively costly X-ray set or purchasing its own radium, either of which could well result in an expenditure of some thousands of pounds. To-day, it is possible, for an outlay of a few hundreds of pounds, to use these new radioisotopes. Furthermore, with these relatively inexpensive sources of gamma rays it is possible to penetrate far greater thicknesses of steel, brass or bronze, than could be radiographed with a medium-sized X-ray set. As a result of employing these more penetrating radiations, the amount of information obtainable per radiograph has increased considerably; the pivot bracket castings shown in Figs. 1 and 3 provide an excellent example. Originally, the coverage of these castings using a 400-kV X-ray set was achieved with eight shots. To-day, using radiotantalum, which has characteristics rather similar to those of radiocobalt, a more comprehensive examination has been secured with only three views per casting. This is a direct result of the additional penetrating power which enables the numerous section junctions in this casting to be covered fully.

The use of these new isotopes is now providing the foundryman with a rapid and relatively inexpensive method of checking the techniques for new designs of castings before going into full-scale production. In many instances they are indicating ways in which old foundry methods can be improved, particularly in respect of obtaining higher yields of steel. I should not like to imply that sound castings capable of giving first-class service have not been made in the past, but rather that the methods which had to be employed to ensure such desirable results were frequently long and expensive, involving as they did, the cutting up and sectioning of pilot castings or the provision of over-sized heads. This new approach enables reliable foundry procedures and methods to be laid down at the start, which will help in securing the regular production of commercially-sound castings at a maximum economy in metal usage and production costs. We have carried out some 500 technique investigations during the past two years. In nearly every instance appreciable savings have been achieved and I believe that this supports my earlier somewhat sweeping statement that "something approaching a revolution in technical foundry control" has been achieved by gamma radiography.

I propose to survey briefly further research work which we are now undertaking, having as its object the improvement and further development of the uses of this new technique for the purpose of speeding up the work and reducing the costs. In this connection tribute should be paid first and foremost to the excellent work which is being carried out by the Radiochemical Centre at Amersham and the Isotope Division of the Atomic Energy Research Establishment at Harwell. We are co-operating closely with these organisations in exploring the radiographic applications of new isotopes such as caesium 137 and cerium 144, because the former will provide good defect-detection sensitivity in thin metal sections while the latter may penetrate great metal thicknesses.

Some mention must also be made of the relatively new technique of radiological scanning. Here the main objective is to eliminate the use of photographic methods and to give a quick survey of a specimen by traversing it through its thickness with a collimated gamma-ray beam, the intensity of which is recorded with the help of Geiger-Muller proportional or scintillation counters. Gamma radiography, however, is by no means the only benefit that will accrue to non-destructive testing techniques from the advances in nuclear-physical research and technology. The foundryman will

* Edward Williams Lecture, delivered on Wednesday, June 17, 1953, at Blackpool during the 50th Annual Conference of the Institute of British Foundrymen. Abridged.

watch with much interest developments in the construction of synchrotrons and linear accelerators that will be capable of providing radiation sufficiently penetrating for the examination of metal sections two or three times greater than those which we have been able to handle so far.

We need not, however, look so far into the future for other applications to non-destructive testing. As long ago as 1939, H. F. Kaiser* drew attention to a novel use of radioactive substances in non-destructive testing. He has described a method of crack detection in which specimens can be dipped in radioactive solutions or coated with greases containing radioactive substances. After removing the solution or grease from the surface of the specimens sufficient radioactive material is left in the cracks or flaws to enable them to be detected by the use of photographic films. The method is of course very similar to the age-old oil and chalk method which, like the radioactive method, is applicable to non-magnetic as well as to magnetic materials.

Tracers.

The radioactive method of crack-detection is typical of the tracer methods I am about to discuss. All of them depend on the fact that by virtue of radiation emitted it is possible to trace minute quantities of radioactive isotopes which in their other physical, chemical and metallurgical behaviour resemble elements in their ordinary state. It is thus possible to obtain detailed knowledge on how individual substances behave in complex industrial processes. This tracer method therefore conforms closely to one of the outstanding principles of experimental science; the abstraction of the relevant from the irrelevant. In tracer studies it is possible with great sensitivity to observe almost exclusively radiation from one selected type of atom in the system. Therein lies its unique attraction.

The handling of gamma ray sources in radiography necessitates safety precautions which are now fairly well understood. In tracer work, however, every individual experiment must be designed with a view to avoiding not only exposure of personnel to excessive radiation but also ingestion of appreciable quantities of radioactive materials. This is a subject which everyone should study before experimenting with any radioactive materials. Sound advice is available in an *Introductory Manual on the Control of Health Hazards from Radioactive Materials*, issued by the Ministry of Supply. Medical hazards are not, however, the only limitation to the mode of planning of tracer experiments. One must refer first to the detecting—and often measuring—of the activity itself which depends on the type, energy and intensity of radiation as well as on the half-life of the nuclide chosen—usually from all too few alternatives. In addition, the physical or chemical behaviour of the radioactive material must often be experimentally typical of the material the course of which is being "traced" through some more or less complicated physical, chemical, metallurgical or biological system. The radioactivity itself must not, furthermore, significantly alter the characteristics of the system. Ideally the radioactive material must in some experiments admix itself evenly over part of the system and in others it must be drawn exclusively to special chemical or physical sites. These points are best explained by examples classified into the three types of tracer experiments.

Taking first, physical indicators. In this class, the course of materials is followed through systems without, however, entailing chemical interaction. The chemical nature of the tracer need not always be identical with the traced substance. The method of crack-detection in metals by radioactive materials discussed in an earlier section is an instance of tracer work in this class. If the radioactive material is to indicate the cracks it must be on the one hand efficiently removed from all surface features other than cracks and it must on the other hand be sure to enter cracks if present. Furthermore, the solution or suspension used must not be corrosive to the metal. Precisely similar planning is used for locating leakage in pipes or cables, for following the descent of the ball in the falling-ball viscometer, for finding liquid levels in high-pressure vessels or possibly even furnaces, and for many other applications.

Even when the aim of the experiment is more complicated than merely the location of the trace material, the procedure may be simple. When for example, Voice* wished to study the rate of refractory attack in blast furnaces it was perfectly satisfactory to use radiocobalt, a cheap and convenient gamma emitter, in pellets embedded at different points and depths. The stated conditions only require that the cobalt shall remain in place as long as the surrounding refractory is intact and that this surrounding refractory should be typical and unaffected by the radioactive material. The radioactivity where it can be observed from outside falls virtually to nothing as soon as the liquid metal penetrates to the location, and in consequence the iron itself will then show a sudden, measurable increase in activity. Air ventilation tests in confined spaces is another example of the uses of physical indicators*. The planning of such experiments is not easy when vapours are used. Even radioactive isotopes of the inert gases will not behave exactly like ordinary air. After the release of the radioactive vapour or gas the experimenter must know to what extent he is justified in considering it evenly admixed with the air throughout the volume under investigation and if the egress of the radioactive constituent typifies that of air.

In some of the seemingly simple applications for physical tracers it is almost impossible to satisfy the conditions that have been discussed. When trying to trace dust, one is in great danger of testing merely the progress of the radioactive dust added artificially without this typifying the prevailing dust. This is one of the chief reasons why the problem of silicosis does not readily yield to tracer methods. It is indeed quite a triumph that experimenters in this field are obtaining data of limited but proved significance by the use of radiotantalum. Another group of experiments in this class deals with difficult determinations of liquid volumes, be it of blood in a body, water in a lake, or steel in a furnace. Experimental significance is achieved only if the radioactive material is not absorbed by the containing walls and is evenly divided in the volume of the liquid.

Turning, in the second place, to indicators of chemical traces; in this class of experiments use

* *Trans. American Soc. for Metals*, vol. 27, page 403 (1939).

* *Radioisotope Techniques*. H.M. Stationery Office, London, 1952, page 23.

* *Loc. cit.*, pages 4 and 12.

RADIOGRAPHY IN THE FOUNDRY.

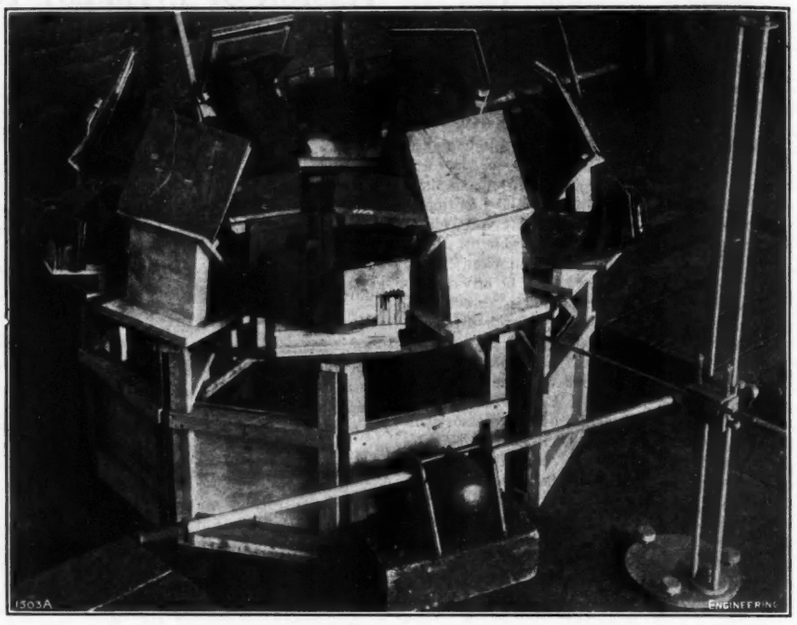


Fig. 1. Gamma Radiography of Aeroplane Undercarriage Pivot Brackets.

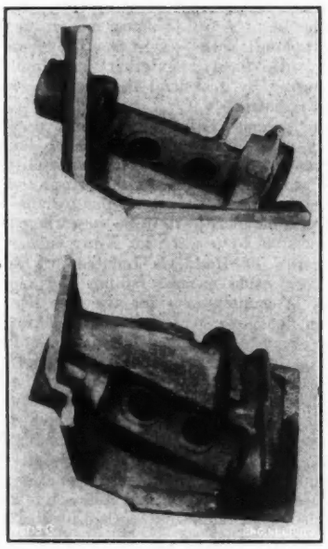


Fig. 2. Pivot Brackets.

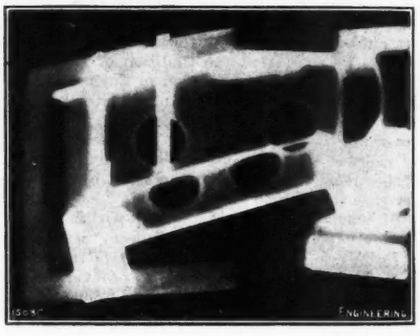


Fig. 3. Radiograph of Pivot Bracket.

is made of the astonishing sensitivity with which radioactive isotopes can be detected. Exact figures depend to a great extent on the elements concerned and the material in which they are to be detected. It is necessary only to add a radioactive isotope in concentrations of one per million and to allow it to attain equilibrium with the corresponding inactive element in a system in order to be able to detect its presence after dilution to one part per thousand million.

Applications of this class of tracer experiment are numerous and varied, but one example suggests itself for mention in this lecture, for the steelmaker has not been slow in using this technique for his problems.* All theories of desulphurisation of iron by slags are based on the idea that the sulphur finally becomes fixed in the slag as sulphide of calcium or sodium; but how this is brought about is not fully understood. One question is: could the sulphide be formed by reaction inside the metal? As this would involve calcium entering the metal, detection of that element in the bulk metal would afford a clue. Chemical or spectrographic estimations are insufficiently delicate to detect its presence at concentrations of less than about one part in ten thousand. Small melts of iron at about 1,600 deg. C. were therefore made in a graphite crucible under slags in which a portion of the lime content contained radioactive calcium. Philbrook and his collaborators failed to detect the presence of any calcium in the metal, at any rate to an amount of more than 0·6 parts per million which was the approximate, and perhaps not very impressive, sensitivity achieved. From this the experimenters concluded that the sulphide reaction had not occurred to any significant extent.

In the third place, we will deal with chemical indicators. Radioactive isotopes in this type of investigation are used to trace the course and locate chemical elements, radicals or compounds throughout systems in which chemical reactions occur. For the purpose of this discussion metallurgical alloying may be regarded as a chemical reaction. In this field many striking experiments on auto-diffusion in metals have been reported. Auto-diffusion is the process by which metal atoms move through a matrix of chemically identical atoms. It can be studied only by tracer techniques. Radioactive isotope material is placed on or sandwiched between layers of inactive metal by rolling, pressing or electro-plating. The depth of penetration of the active into the inactive material is measured after known periods of time under carefully controlled physical conditions. Diffusion has been shown to proceed fastest along the grain boundaries owing to the atomic disorder which, however, is directly influenced by radioactivity itself. It is not surprising, therefore, that some experiments in which the radioactivity is induced on one side of the specimen by neutron bombardment have been shown to be subject to an appreciable experimental error.

The results of these experiments may not directly affect the foundryman, but they give new data for just the sort of theoretical considerations as are needed for progress in knowledge on metals and alloys. Who can doubt that ultimately every foundry will benefit from such advances in knowledge?

To return, however, to more immediately useful applications of tracers: in the steel industry the problem of "tracing" steel through casting, heat treatment and other processes may arise. The question, for instance, where does the liquid steel go to that is poured into the tops of heads of castings and ingots, if it could be answered, would help to solve many problems of practical importance.

Experiments involving small additions of radioactive elements to steel are now being made. Partly because other investigators are already experimenting with radioactive iron and cobalt in steel and partly because of the inherent advantages of radiocarbon—that is, its long half-life and the purity and shortness of range of its radioactive emanations—the author has chosen the seemingly more difficult course of using radioactive carbon and employing a modification of a technique originated by J. K. Stanley.* In the mild-steel capsule used by the author, a radioactive carburising charge consisting of barium carbonate containing carbon 14 and inactive graphite is sealed. Heat treatment follows for 8 hours at 900 deg. C. in an atmosphere of nitrogen. The extent of carburisation achieved is shown on the autoradiograph after sectioning the container perpendicularly to the cylinder axis, Fig. 4, on this page. This autoradiograph also illustrates the decrease of the case-hardening effect with increasing distance from the inner cylinder surface.

The radioactive steel so obtained can be re-melted and run into the heads of castings, which are subsequently sectioned for preparation of autoradiographs. The results already obtained prove not only that carbon segregation can be shown up strikingly by this method but also that the head metal feeds deeply into the body of the casting.

* W. O. Philbrook, K. M. Goldman and M. M. Helzel. *Trans. A.I.M.E.*, vol. 188, page 361 (1950).

Nuclear Energy.

During the last few years many serious warnings have been issued by scientists all over the world that not only are we wasting our present fuel resources, but also that, even with the exercise of great economies, the coal and oil resources of our globe are likely to be exhausted in the next hundred years. Fortunately, the advances that are now being made both in the United Kingdom and the United States are such that it is believed that

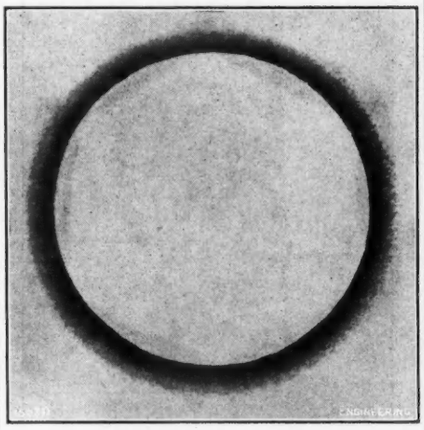


Fig. 4. Autoradiograph of Carburised Steel Container.

nuclear fuel will be able to replace coal and oil as a means of power production within such a period of time.

A recent report of the President's Material Policy Commission of the United States has provided some intriguing estimates of the possibilities. Table I shows some of the more outstanding

Table I.—*World Fuel Resources.*

One unit	10^{12} B.Th.U.
Present annual world consumption of fuel	0·2 units
World reserves of coal	33·0 ,,
World reserves of oil	5·6 ,,
(*a*) Supplies of uranium available at a cost of 100 dols. per lb.	25,000,000 tons
If (*a*) 100 per cent. utilised	1,700 units
(*b*) Supplies of uranium available at a cost of 50 dols. per lb.	3,700,000 tons
If (*b*) 100 per cent. utilised	250 units

statistics. When we consider that the present needs of this country could be met by 10 to 15 tons of uranium a year the importance of nuclear energy is brought home forcefully to us as large consumers of electrical energy in the metallurgical industries.

Sir John Cockcroft in a lecture given to the Institution of Electrical Engineers in January of this year on the subject of "Nuclear Reactors and their Applications"† has provided the most up-to-date picture of progress in this field. He discussed in some detail reactors for power production and explained that in the next stage of development it would be possible to use normal natural-uranium power reactors rather similar to those already in operation at Harwell and Chalk River. By the use of a pressurised external envelope, either gas or water could be employed to absorb the heat from the reactor, and by means of a heat-exchange system steam could be produced and used in the conventional power-station turbines. The fuel elements would have to operate at 350 to 450 deg. C. to ensure reasonable thermodynamic efficiency. The size of such a unit would be comparable with that of the present British Electricity Authority set.

* *Metal Progress*, vol. 52, page 227 (1947).

† See ENGINEERING, page 84, *ante*.

Materials for the Atomic Pile.

While the next part of this lecture will probably be of more interest to the metallurgist than the foundryman, it may well be that the latter, in the foreseeable future, may be asked to cast shapes in some of the newer metals and alloys that up till now have been looked upon as metallurgical rarities. So far, one of the most important considerations in choosing an alloy for a particular purpose has been that of ease of casting. The foundryman of the future may well find himself in the position of being asked to cast alloys that are not of his own selection and which will involve the development of new techniques to obtain the required soundness.

Nuclear-energy plants whether they be primary graphite or heavy-water piles for the production of plutonium, or whether they be reactors designed to produce energy from the burning of nuclear fuel, present a number of novel problems to the metallurgist, the designer and the manufacturer. In conventional power stations or chemical-engineering plants the failure of a blade or the cracking of a weld may cause a temporary close-down, but in a plant burning or processing radioactive materials the consequences are infinitely more serious since the intense radioactivity makes maintenance, as ordinarily understood by the engineer, virtually impossible. The standards of soundness and reliability, and the inspection requirements are, in consequence, much more rigid. These aspects have been dealt with by Sir Christopher Hinton* in his recent May lecture to the Institute of Metals.

In atomic piles everything depends on ensuring that the best use is made of the neutrons which sustain the chain reaction; these must not be wasted in capture by foreign atoms in the materials of construction. Certain elements such as boron and some of the rare earth metals have a strong capacity for capturing neutrons, whereas light metals such as beryllium, magnesium, zirconium and aluminium are relatively transparent to neutrons; this latter group is thus particularly attractive for materials for sheathing the nuclear fuel elements. Similar considerations apply to the uranium rods and the graphite moderator when it is necessary to ensure that "poisoning" elements such as boron, cadmium and some of the rare-earth elements are present only to the extent of a few parts per million. Yet these elements have their uses as control rods or shields where neutron capture is essential for keeping the chain reaction under control or for preventing damaging radiation from escaping to the atmosphere. Nature certainly provides us with some strange partners. A good example is zirconium, a metal that is becoming increasingly important because of its very low capacity for capturing neutrons. Associated in nature with zirconium is found hafnium, which has a very high capacity for absorbing neutrons. Complete, or nearly complete, chemical separation of the two is not easy. While boron or cadmium are normally used in control rods to-day, the use of hafnium or one of its alloys for the same purpose in the future is a real possibility.

I am a firm believer in the future possibilities of nuclear energy as an economic source of power production. Coal resources are drying up; and while wind, sun and water will continue to make useful contributions, something must be found to take the place of oil and coal. I believe nuclear energy will do this for us. Thus, I close in expressing my lively faith that the good that will arise from these new scientific developments will far outweigh the evils that could arise if they were used for purposes of destruction.

* See ENGINEERING, page 575, *ante*.

NOTES ON NEW BOOKS.

Relationship Between the Chlorine Content of the Coal Burned and the Availability of a Stoker Fired Boiler. (Technical Paper No. 3.)

The Boiler Availability Committee, 8, Waterloo-place, Pall Mall, London, S.W.1.

EARLY research work carried out under the auspices of the Boiler Availability Committee indicated that stoker-fired boilers, when burning coal containing much chlorine, suffered severely from high-temperature deposits. The chlorine exists generally as chlorides of sodium and potassium, and, although it is these elements which are important from the point of view of deposit formation, the chlorine combined with them is much more easily determined by analysis and serves as a practical measure of potential trouble. A chlorine content in coal of 0·3 per cent. is regarded as high, and one of less than 0·15 per cent. as low; the highest percentage found in British coals is 1·1. In order to study the extent to which the rate of formation of alkali-bonded deposits could be correlated with the chlorine content of the coal burned, a long series of tests was carried out at Burton generating station by the Burton Investigation Group, who work in conjunction with the Boiler Availability Committee. The results of the tests are given in detail in this report, which will be of value to all operators of stoker-fired boilers. The situation of the Burton station is such that supplies of coal of widely different chlorine content were available and the size of the boilers enabled them to be conveniently fired with one type of coal. Previous to the tests, it had been found impracticable to operate the boilers continuously at their maximum rating owing to the rapid formation of bonded deposits, and microscopical examination indicated that the main cause of the build-up of these deposits was the high content of volatile alkali compounds in the fuel. The tests were made with three types of coal having chlorine contents of 0·95 per cent., 0·46 per cent. and 0·03 per cent., respectively. The length of run at maximum continuous rating obtained with the first of these coals was 532 hours; with the second, it was 1,200 hours; and with the third, 8,240 hours. This last-mentioned run could have been extended, but was discontinued as the boiler was due for annual survey. As a demonstration of the effect of alkali volatiles in deposit formation, the tests were decisive.

Pictorial Drawing for Engineers.

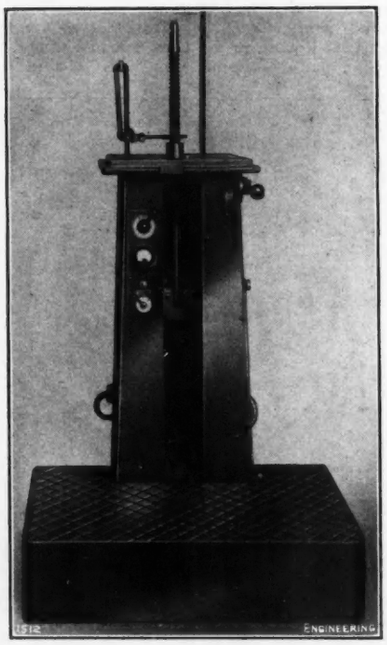
By A. C. PARKINSON. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 16*s.* net.]

WITH this volume Mr. Parkinson adds another to his text-books on engineering drawing, this time on the projection of "solid" pictures to assist in visualising the completed article. After dealing with the general classification of systems, consideration is first given to isometric projection, and then to metric projection generally. Constructions are given clearly and in detail for obtaining these true-to-scale views, for most standard shapes. Special scales and instruments that have been devised to reduce the labour involved are described. The Leete and Walters systems are described in some detail. Chapters on oblique projection and other pictorial methods follow, again with a mention of the mechanical aids available. Chapter 7 is devoted to perspective drawing, and the Tharratt method of "production illustration," extensively used during two World Wars to overcome the inability of "dilutee" labour to read drawings in orthographic projection, is outlined. The concluding chapter reverts to orthographic drawing (both the first-angle and third-angle systems being reviewed), and the use of auxiliary views. An appendix contains a number of useful examples for practice in projection, and there are exercises at the ends of the chapters.

FOURTH NATIONAL POWER FARMING CONFERENCE.—The next national conference on power farming will be held at the Town Hall, Cheltenham, on February 9, 10 and 11, 1954. As on previous occasions, the conference is being organised by the *Power Farmer: Britain and Overseas*, Dorset House, Stamford-street, London, S.E.1.

VERTICAL BROACHING MACHINE.

FOR producing keyways, serrations, and profiles economically, the Rausch vertical broaching machines made by Stahlkontor Weser G.m.b.H., Hameln, Germany, are now available in the United Kingdom. The sole agents are Messrs. Leo. G. Steinle, Limited, Marston Green, Birmingham, and the distributors are Messrs. Burton, Griffiths and Company, Limited, also of Marston Green. The machine requires little floor space, and imposes no restriction on the diameter of work which can be accommodated. Since the work does not require to be clamped to the table, setting-up operations are simplified. Two sizes of machine, the S.R.6 and the S.R.10, are available, with strokes of 19¾ in. and 35½ in., accommodating a maximum length of broach of 26½ in. and 42 in., respectively. The larger machine is shown in the accompanying illustration. Both machines are suitable for producing keyways ranging from ⅛ in. to 1¼ in. wide, are provided with a 19¾-in. by 15¾-in. work table, and are driven by a 5·5-h.p. motor flange-mounted on the rear wall of the



column, and giving a pulling capacity of 17,600 lb. The cutting speed is 4·9 ft. per minute and the return speed 9·8 ft. per minute, in both cases. The production time per piece for work requiring one pass is 70 to 72 seconds.

The drive is transmitted, through a coupling system completely enclosed in an oil-filled gear-casing, to two strong square-threaded vertical screw spindles, between which is a bridge with threaded bronze sleeves. Self-centring jaws for gripping the broaches are incorporated in the bridge, and release the broach automatically on completion of a broaching pass. In both end positions, the drive is automatically disengaged. All the rotating parts are supported in ball or needle-roller bearings, and the end thrust is taken by ball thrust bearings. The table top has diagonal T-slots for mounting special fixtures for external broaching, and an annual groove to receive an indexing attachment, which can be supplied as extra equipment, for 2, 3, 4, 5, 6, 8, 10 or 12 divisions. A centre bore is provided in the table for centring the expanding mandrel and for the passage of the broaching tools.

PNEUMATIC HOIST.—We are informed that the pneumatic hoist made by Marton Air Equipment, Ltd., Parkshot, Richmond, Surrey, which we have described in its horizontal form, is now also made as a vertical pendant unit.

BOOKS RECEIVED.

Flames: Their Structure, Radiation and Temperature. By DR. A. G. GAYDON and DR. H. G. WOLFHARD. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 55*s.* net.]

Port of Cochin. Administration Report for 1951-52. The Administrative Officer, Port of Cochin, India.

Mechanical Properties of Wood and Paper. By DR. W. W. BARKAS, R. F. S. HEARMON, and DR. H. F. RANCE. Edited by R. MEREDITH. North-Holland Publishing Company, P.O. Box 103, Amsterdam, Holland. [Price 25 florins.]

United States National Bureau of Standards. Handbook No. 52. *Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water.* The Superintendent of Documents, Washington 25, D.C., U.S.A. [Price 20 cents.]

Proceedings of the International Symposium on Abrasion and Wear. Held at the Rubber-Stichting, Holland, 1951. Reprinted from ENGINEERING. Rubber-Stichting, Post Box 66, Oostsingel 178, Delft, Holland. [Price 6 florins.]

United States National Bureau of Standards. Applied Mathematics Series No. 26. *Table of Arctan x.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1·75 dols.]

Sound. By DR. E. G. RICHARDSON. Fifth edition. Edward Arnold and Company, 41, Maddox-street, London, W.1. [Price 25*s.* net.]

Mesure des Vibrations et Isolation des Assises de Machines. By DR. A. TENOT. Dunod, 92, Rue Bonaparte, Paris (6e). [Price, 1,950 francs.]

Physique Industrielle. By JULIEN IZARD. Dunod, 92, Rue Bonaparte, Paris (6a). [Price 480 francs.]

United States National Bureau of Standards. Applied Mathematics Series No. 20. *Tables for Rocket and Comet Orbits.* By SAMUEL HERRICK. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1·75 dols.]

United States National Bureau of Standards. Circular No. 540. *Weights and Measures Case Reference Book* (Through July, 1952, Court Decisions). The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1·25 dols.]

TRADE PUBLICATIONS.

Rubber Conveyor and Elevator Belting.—The Dominion Rubber Co., Ltd., 62 and 64, Horseferry-road, London, S.W.1, have recently issued a comprehensive catalogue and handbook on rubber belting for conveyors and elevators. The various classes of belt manufactured by the firm for different applications are illustrated and described and much useful technical information is given in the form of tables, graphs, and notes on installing, training, jointing and splicing the belts.

Chemically-Resistant Cement.—We have received a booklet from the Dunlop Rubber Company, Limited, London, S.W.1, concerning the products of their subsidiary company, Semtex, Limited, who manufacture latex, plastic, silicate, resin and sulphur Semtex cements to resist the action of alkalis and acids. The material is supplied in the form of a viscous liquid in drums, and as a powder in suitable bags. The chief use of this material is for the priming of ceramic and corrosion resistant tiles and bricks, when the joints become as resistant as the tiles or bricks used, while the silicate variety is also able to withstand temperatures of up to 1,600 deg. F.

Grab Dredgers.—We have received from Priestman Brothers, Limited, Hull, a copy of their new catalogue illustrating their various grab dredgers for steam, Diesel or electric operation; a feature of these dredgers are the depth of working and slewing indicators which tell the operator precisely when the grab last operated and its current position, thereby enabling accurate pattern dredging to a predetermined depth.

Magnifying Glass for Precision Work.—We have received a leaflet from J. A. Rogers, 26-28, Grange-road, West Kirby, Cheshire, describing their Rogatool Focascope, a magnifying lens designed for attaching to spectacles, or for wearing with a headband, which can be swung up out of the user's line of vision when not required.

Fans.—We have received from the London Fan and Motor Co., Ltd., 91a, Burghley-road, London, N.W.5, a leaflet giving particulars of their range of industrial propeller fans.

pH Indicator.—Particulars of a new design of *p*H indicator, which embodies an improved electrode system and is intended for routine work, have been received from the Cambridge Instrument Co., Ltd., 13, Grosvenor-place, London, S.W.1.

Electric Connecting Wires.—British Insulated Callender's Cables, Ltd., Bloomsbury-street, London, W.C.1, have sent us a pamphlet giving details of the standard connecting wires which they manufacture to comply with Ministry of Supply (Air) Specification EL.1701.